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Welcome to Volume 11 Issue 1 of Journal of ENT Masterclass® 2018

I very much welcome all our readers to the 11th edition of the Journal of ENT Masterclass®. In the previous 10 editions, we published more than 200 articles that were provided as a free-of-charge printed journal and were later accessible online. Financial constraints meant that there was always a finite number of issues that could be distributed, and online access was ultimately more readily available to readers. As the world of published research continues to evolve, it appears that online access is gradually taking over from printed material. This 11th edition is, therefore, going to be immediately available as a free online journal with no further printed issues. This will also give the publishers flexibility in editing, adding more material and, in the near future, incorporating videos within the articles.

For this edition of the Journal of ENT Masterclass, we are pleased to have a selection of comprehensive articles written by national and international authors. As always, the breadth of specialty is covered, and new subjects such as laryngeal clefts, management of keloid, paediatric balance disorders and robotic surgery are included. We are very grateful to all authors and must say that we are always in debt to our editors who tirelessly continue their selfless work for the journal.

On other fronts, the ENT Masterclass courses continue to be as popular as ever, with long waiting lists for attendance. The travelling Masterclass has reached the far corners of the Earth, with the 2019 planned journeys to Bahrain, Pakistan, South Africa, China, Germany, Romania, Switzerland and Uzbekistan.

I hope you will enjoy reading this 11th edition, and we will always welcome your comments and suggestions.

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Child maltreatment for the ear, nose and throat surgeon

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Abstract
The abuse of children, known as child maltreatment, is common. Doctors have an implicit duty to protect the health and welfare of children, and as practitioners of a speciality with a large paediatric population; this responsibility is particularly relevant for Otolaryngologists. A review of the available literature on child maltreatment is undertaken, focussing how these children may present to the ENT surgeon. A summary is provided on the topic of physical abuse and neglect in children. Pertinent legislature is reviewed and important features of the physical examination are highlighted. When present, child maltreatment represents a complex diagnosis and should be considered holistically within a multi-disciplinary team.

J ENT Masterclass 2018; 11 (1): 4 - 8.

Key words
Child maltreatment, child welfare, otolaryngology, non-accidental injury

Introduction
Child maltreatment is the abuse and neglect that occurs to individuals under 18 years of age. It includes all types of physical, sexual, and emotional abuse, neglect, negligence, and commercial or other exploitation, which results in actual or potential harm to a child's health, survival, development or dignity in the context of a relationship of responsibility, trust or power[1].

Children have a right to be protected from maltreatment as stated in the United Nations' Convention on the Rights of the Child[2] and most countries have passed legislation in order to protect children. To this end, the United Kingdom government has enacted the Children Act 1989, which enshrines in law the concept that child welfare is paramount, and further, sets out how Children's Social Care will protect children. There has been subsequent legislation and a number of revisions of the statutory guidance Working Together to Safeguard Children, which includes the definitions of various forms of child maltreatment[3]. The General Medical Council (GMC) published Protecting Children and Young People in 2012[4] which states:

> *"Good medical practice places a duty on all doctors to protect and promote the health and well-being of children and young people. This means all doctors must act on any concerns they have about the safety or welfare of a child or young person."*

Child maltreatment is common. In 2017, over 51,000 children in England (over 4 per 1,000) were identified as needing protection from abuse (i.e. placed on a Child Protection Plan following an initial child protection conference)[5,6]. However, self reporting suggests the problem is much greater[6].

The 2015-16 Crime Survey for England and Wales ran, for the first time, a module of questions asking adults whether they were abused as a child[6]. The survey showed that 9% of adults aged 16 to 59 had experienced psychological abuse, 7% physical abuse, 7% sexual assault and 8% witnessed domestic violence or abuse in the home. The survey reported that perpetrators were most likely to be a parent for those that had suffered psychological abuse (father 35% and mother 40%) or physical abuse (father 39% and mother 29%)[6].

The impact of these insults, both emotional and physical, can be difficult to quantify but can undoubtedly persist into adult life with potential effects on physical and, importantly, mental health. Victims can continue to suffer as the result of direct biological injury and often develop high-risk anti-social behaviours, inappropriate coping mechanisms and poor parenting emotions and skills[7].

As a speciality with a large paediatric population[8], Otolaryngologists play a critical role in ensuring children within their care are safeguarded from abuse and neglect. An awareness of how child maltreatment can present in the ears, nose and throat is therefore imperative. Furthermore, an insight into characteristic features of non-accidental injury (NAI) in other anatomical locations is equally important, as these may be observed on general or extended examination.

Aims & Methods
This clinical review article was written to highlight the important points for the practising ENT clinician. A literature review was performed to ascertain the current experience of child maltreatment under the care of Otolaryngologists. Further articles were selected for inclusion following review of reference lists of full text studies. This article does not attempt to be an exhaustive review of the literature but highlights the most significant issues.

As clinical trials cannot be conducted in this field, studies tended to be non-controlled observational case reports or case series. Some studies that were mainly concerned with accidental injuries are included as a comparison of accidental versus non-accidental injury. It should be noted that the majority of larger case studies were published before 2000 although it is beyond the scope of this review to interrogate this further.

General Principles of Child Maltreatment
In 2018 the National Institute of Clinical Excellence (NICE) updated its clinical guideline When to suspect child maltreatment providing general guidance on when to consider or suspect child maltreatment[9]. This guidance states that child maltreatment should be suspected if there is bruising not caused by a medical condition, and if the explanation for the bruising does not marry with the clinical presentation. Examples within this guideline include:

- bruising in a child who is not independently mobile (i.e. an infant or a child who is disabled).
- multiple bruises or bruises in clusters.
- bruises of a similar shape and size.
- bruises on any non-bony part of the body or face including the eyes, ears and buttocks.
- bruises on the neck that look like attempted strangulation.
- bruises on the ankles and wrists that look like ligature marks.

NAI in the Head and Neck
A number of studies, including Dunstan et al (2002)[10] and Kemp et al (2015)[11] have shown that the head & neck is the commonest site for abusive bruising in children. Both studies reported the left side of the head and neck to be more commonly bruised in abuse than the right – presumably as most perpetrators are right-handed.

Willging et al (1992)[12] reviewed all referrals from an Emergency Department to Children's Social Care over a 5 year period from an Otolaryngology perspective. Of the 1390 physically-abused patients, 641 (49%) had evidence of injury to the head & neck and the primary complaint leading to referral was within the head & neck region in 555 (40%). They noted that the majority of non-accidental injuries were bruises, abrasions or simple lacerations. Additionally, 57 (4%) of patients were discovered to have fractures in the head & neck region and burns to this region were identified in 33 (2%).

Leavitt et al (1992)[13] reviewed 85 children admitted to hospital with physical abuse, again from an Otolaryngology perspective. 31 (36%) had evidence of abuse to the head & neck, and 21 of these involved the ear.

Rees et al (2017)[14] recently performed a systematic review to identify ENT injuries, signs or symptoms that are indicative of physical abuse, fabricated or induced illness. This extensive review of mainly case and cohort reports identified that pharyngeal injuries were the most frequent ENT injury resulting from physical abuse. The children with abusive pharyngeal injuries tended to be <1 year old and have co-existent injuries (ranging from bruising to rib fractures). As with most reviews of fabricated and induced illness in children, there were a variety of presentations, often in children with complex medical histories. The symptoms and signs were difficult to ascribe to a known medical condition and resistant to subsequent treatment.

Mucosal pharyngeal injury is uncommon but if present, is thought to be the result of child maltreatment in up to 80% of cases[15]. Palatal petechiae or lacerations should raise concern regarding potential oral sexual penetration[16].

Excessive dental caries within the correct context can be a sign of neglect[16].

NAI in Otology

Steele and Brennan (2002) reported a prospective survey of 111 children presenting with presumed accidental external or internal ear injuries to a paediatric Accident & Emergency department[17]. The mechanism of injury was variable but the most common injury was laceration of the pinna (56%). Most cases presented within six hours of injury (84%). No child presented with bilateral injuries and only one of their patients was under the age of 1 year. This contrasts with the types of ear injuries reported in association with child maltreatment.

Manning et al (1990) and Feldman (1992) both describe bilateral bruising to the pinna[18,19] and Manning et al (1990) and Grace et al (1987) report cases of young children with bilateral recurrent tympanic membrane perforations due to physical abuse[18,20].

Spontaneous haemorrhage from the ear may occur after acute otitis media, but this is normally associated with purulent discharge. Recurrent bleeding from the ear should be considered as a manifestation of abuse when no satisfactory parental explanation is forthcoming and results of coagulation studies are normal. Laceration of the anterior meatal wall should especially arouse suspicion given the rarity with which this site is injured accidentally[18].

Khera et al (2017) reviewed all children referred to their service for child protection medicals over a 10-year period and identified 29 cases with bruising to the ear[21]. NAI cases presented with at least 3 ear bruises, typically around the scaphoid fossa or on the posterior surface. They also reported that a child with NAI ear bruising is more likely to have NAI bruising at another anatomical site.

Hearing loss secondary to child maltreatment is rare, but has been described, with a single instance in a series of 28 children from a Canadian institution[22]. Otherwise, hearing loss in the absence of trauma does not seem to occur as a presentation of NAI and should not be considered as such.

Caustic injury to the ear represents a particularly rare form of injury within the literature[23]. One study reports an acidic substance inflicted upon two siblings, resulting in caustic damage to the external, middle and inner ears[24]. Although the original substance was undefined at time of publication, the patients were left with facial nerve palsies, persistent profound sensorineural hearing loss and intractable otorrhoea, the latter resulting in both patients undergoing blind sac closures[24].

NAI in the Sinonasal Cavity and Pharynx

Nasal injury due to child maltreatment is not commonly reported. Most inflicted injuries are superficial bruising or abrasions. Willging et al (1992) reported four nasal fractures and fewer nasopharyngeal lacerations[12]. Canty et al (1996) described 20 consecutive cases of haematoma and abscess of the nasal septum (HANS) in children over an 18-year period, 2 of which were a consequence of child abuse (and both in children under 2 years of age)[25]. Orton (2003) described a case report of loss of the columella and septum from over-zealous scraping with a metal Kirby grip[26]. One of the authors (MFR) was involved with a case of non-accidental perforation of the cribriform plate with intracranial injury but this is as yet unpublished.

Ng et al (1997) described 12 cases of visceral manifestations of non-accidental injury, including two cases of pharyngeal laceration in infants, one of which also had a pharyngeal foreign body[27]. There are many other case reports of small numbers of generally young children with pharyngeal trauma where non-accidental injury is the cause.

A systematic review of intra-oral injuries, including those to the frenulum, was conducted by Maguire et al (2007) which found that intra-oral injury occurs in a significant number of children who have been physically abused[28]. Injuries are widely distributed to the lips, gums, tongue and palate and include fractures, intrusion and extraction of the dentition, bruising, lacerations and bites. Although there are a number of case reports that describe a torn frenulum in children who have been abused, the authors could not ascribe a probability of abuse to a torn labial frenulum. The finding of an unexplained torn labial frenulum in a young child obviously warrants full investigation but as with injuries to many parts of the body, there is insufficient literature to define a likelihood of child maltreatment.

Oronasal haemorrhage and asphyxiation

Epistaxis is rare in children aged 2 years and under[29]. An association between epistaxis and attempted asphyxiation was first reported in a study using covert video surveillance where 11 of 30 young children who had been asphyxiated developed oral or nasal haemorrhage. Rees et al (2016) published a systematic review to determine the proportion of children aged less than 2 years, presenting with epistaxis in the absence of trauma or medical explanation, who had additionally been asphyxiated and to attempt to identify the clinical characteristics indicative of asphyxiation[30]. Only six studies were included in the review, identifying 30 children with asphyxiation-related epistaxis and 74 children with epistaxis unrelated to asphyxiation. The proportion of children presenting with epistaxis that had additionally been asphyxiated, reported by 3 studies, was between 7% and 24%. The authors concluded that epistaxis does not constitute a diagnosis of asphyxia in itself but recommended that asphyxia should be part of the differential diagnosis in any infant presenting with unexplained epistaxis.

Children who are not brought to medical appointments

All doctors should recognise that children who are not brought to medical appointments may be at increased risk of abuse compared to the general population[31]. Most Child Health departments in the UK now use the abbreviation WNB – Was Not Brought, rather than DNA – Did Not Attend, as the former reminds staff of the increased vulnerability of children and the need for NHS Trusts to have child specific WNB guidelines[31].

Conclusion

The GMC have defined the duty of all doctors with relation to child maltreatment. The following features should trigger further enquiry:

1. Young children and disabled children are at increased risk of abuse and must be assessed with a higher index of suspicion
2. Unexplained injuries or those with an implausible, inconsistent or inadequate history
3. Clinical signs which are suggestive of inflicted injury or neglect
4. Risk factors present amongst care-givers, particularly domestic violence, alcohol and/or drug misuse or mental health conditions

Otolaryngologists should be aware of ENT presentations associated with increased risk of causative maltreatment and should retain an understanding of their institution's Child Protection Policies. Children who are currently at risk, or vulnerable, should be managed with specialist paediatric colleagues within a multi-agency team.

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ENT manifestations of paediatric immune dysfunction

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Abstract
Immunodeficiency in children is rare. Most recurrent infections in young children are not due to primary immunodeficiency syndromes, although physiological immunodeficiency of infancy is common, often lasts well into childhood and sometimes requires the use of prophylactic antibiotics if surgical intervention is not indicated. The clinical features of immunodeficiency syndromes are outlined, together with a structure for the investigation and further management in conjunction with paediatric medical subspecialists.

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Key words
Primary immunodeficiency, Secondary immunodeficiency, Classification, Investigations

Introduction
Immunodeficiency disorders in children are individually rare, but as a group comprise a significant group of patients. Children with primary immunodeficiency may present to ear, nose and throat specialists in the first instance due to recurrent or severe infections.

This review will outline the different types of immunodeficiencies found in children, how these may present to otorhinolaryngologists, and provide some guidance regarding which children need referral for further investigation.

Types of Immunodeficiency
Immunodeficiency in children can be classified into primary immunodeficiency, where the disorder is congenital, genetic or inherited; or secondary and acquired after birth. Primary immunodeficiency can be further classified according to the nature of the disorder and which part of the immune system is affected (e.g. innate, humoral (antibody) or cellular immunity, table 1). In recent years, next generation sequencing techniques have transformed the diagnosis and understanding of primary immunodeficiency disorders[1]. In the UK, the prevalence of primary immunodeficiency (PID) in children is thought to be between 3 -4/100,0002.

Secondary or acquired immunodeficiencies are classified according to their cause, the most important of which globally is HIV/AIDS. Approximately 1100 children and teenagers are living with HIV in the UK and around 5000 in North America[3]. Other secondary immunodeficiencies include iatrogenic immunosuppression such as cancer chemotherapy or biological agent use in rheumatology or gastroenterology in the developed world and malnutrition in developing world settings.

There is an additional larger group of children who present with recurrent infections, such as otitis media or recurrent respiratory infections in early childhood without a defined immunodeficiency syndrome whose symptoms often resolve during childhood labelled as physiological immunodeficiency of infancy[4] or simply “maturational immunodeficiency”.

Presentation of Immunodeficiency
The presentation of children with immunodeficiencies depends on the nature of any underlying condition. There is a wide spectrum of severity of these conditions, ranging from imminently life-threatening infections in early infancy to subclinical infections throughout childhood. There are also a relatively large group of children who present to general practitioners, paediatricians and otorhinolaryngologists with frequent infections but who have no underlying disorder. It is important to be able to

Table 1: Basic classification and examples of primary immunodeficiency disorders[1] (adapted from Bousfiha A, Jeddane L, Picard C et al. The 2017 IUIS Phenotypic Classification for Primary Immunodeficiencies. Journal of Clinical Immunology. 2018;38:129-143. PubMed PMID: 26445875).

Types of Immunodeficiency			
Primary		**Secondary**	
Classification	**Examples**	**Classification**	**Examples**
Combined cellular and antibody	a) Severe combined immunodeficiencies (multiple single gene defect causes) b) Common variable immune deficiency (CVID) syndromes c) Combined immunodeficiency with associated or syndromic features (eg Wiscott-Aldrich, Ataxia telangectasia, Cartilage hair hypoplasia, hyper IgE, Di George)	**Infectious**	HIV/AIDS, CMV
Antibody	a) Hypogammaglobulinaemia (eg X-linked agammaglobulinaemia due to BTk gene deficiency) b) Other predominantly antibody deficiencies Transient hypogammaglobulinaemia of the infant (THI), Specific antibody deficiencies.	**Iatrogenic**	Chemotherapy, Biologic agents
Disorders of immune dysregulation	a) Haemophagocytic lymphohistiocytosis (HLH), susceptibility to EBV b) Syndromes with autoimmunity (eg Autoimmune lymphoproliferative syndrome, ALPS)	**Transplantation**	Bone marrow, Solid organ
Phagocyte number and/ or function	a) neutropenia (Schwachman-Diamond) b) Functional defect (Chronic Granulomatous Disease (CGD), Leukocyte adhesion deficiency (LAD), Cystic fibrosis (CF), Primary Ciliary Dyskinesia (PCD)	**Malignancy**	Haematological, Solid organ
Intrinsic/Innate immunity	a) bacterial predisposition (IRAK4, congenital asplenia) b) parasite and fungal predisposition (mucocutaneous candidiasis) c) mycobacterial susceptibility (IL-12, IRNGR2) d) viral susceptibility (STAT1, UNC93B1)	**Autoimmune**	SLE
Autoinflammatory Disorders	Familial Mediterranean Fever (FMF), TNF receptor-associated periodic syndrome (TRAPS), Familial cold autoinflammatory syndrome (CAPS), Periodic Fever and Apthous Ulceration (PFAPA, probably classified here)	**Miscellaneous**	Malnutrition, Asplenia, Diabetes mellitus
Complement deficiencies	a) High infection risk (specific complement factor deficiencies) b) Low infection risk (other factor deficiencies)		

distinguish children who require further investigation from those experiencing infections within the normal limits of childhood.

General considerations

Although immunodeficiency is rare, specific features of a clinical history raise clinical suspicion and should lead to investigation. The criteria for definite referral to a paediatric immunology and infection specialist for detailed immunological investigations are shown in table 2[5]. These factors have a relatively low sensitivity and specificity[6]. However, in the context of a child presenting with "worse than normal infections", these provide a useful context in which to consider the individual child.

Recurrent infections

The majority of children presenting to ear, nose and throat (ENT) specialists with recurrent infections will be "normal" children without underlying immunodeficiency, with a proportion having symptoms due to atopy and allergy. A small number will turn out to have immunodeficiency[4]. This is particularly the case where the infections are primarily viral in origin. It is normal for children to suffer 4 – 11 respiratory infections a year depending on age, especially if they attend daycare or nursery, or have older siblings[7].

In infants presenting with recurrent sinobacterial infection this will most commonly be due to physiological transient hypogammaglobulinaemia of infancy– a prolonged physiological nadir of IgG. This occurs between 3-6 months and normally resolves by one year of age, but can present with recurrent otitis media and respiratory tract infections during this time. It can also be due to prematurity, as infants born early miss the transfer of maternal IgG during the final trimester[8].

Other defects of humeral immunity which are known to present with recurrent ENT infections include the rare condition X-linked agammaglobulinaemia (XLA) and the even rarer autosomal recessive agammaglobulinaemia (ARA) (table 1). Children with antibody deficiency often present during the first 2 years of life with recurrent sinopulmonary infections due to encapsulated bacteria such as *Haemophilus influenzae* or *Streptococcus pneumonia*, and those with XLA are also notable for the absence of lymphoid tissue on examination[9]. Combined variable immunodeficiency (CVID) is a heterogenous group of disorders of B cell antibody production, usually presenting with recurrent sinopulmonary infections, most often in late childhood to adolescence or early adulthood[10]. Conditions of primary antibody deficiency have also been reported to present with recalcitrant chronic rhinosinusitis[11].

Table 2: Children who should be considered for referral for immunology investigations[5]

- Four of more new ear infections within 1 year
- Two or more serious sinus infections within 1 year
- Two or more months on antibiotics with little effect
- Two or more pneumonias within 1 year
- Failure of an infant to gain weight or grow properly
- Recurrent, deep skin or organ abscesses
- Persistent thrush in mouth or fungal infection on skin
- Need for intravenous antibiotics to clear infections
- Two or more deep-seated infections including septicaemia
- A family history of primary immunodeficiency

Phagocytic disorders can also present with recurrent infections, in particular with catalase-positive organisms such as *Staphylococcus aureus*, *Serratia marcescens* and *Nocardia*. Chronic granulomatous disease (CGD) is a disorder in the production of NAPDH oxidase, involved in oxidative killing by phagocytes. It may present with rapidly progressive deep soft tissue infections of the outer ear and mastoid, and may include other oral or facial infections[12].

HIV is the most common immunodeficiency in children worldwide. Recurrent ENT infections are present in about 40% of patients. Persistent, bilateral lymphadenopathy (usually of the posterior triangle) is also often seen in HIV in children, as is recurrent otitis media and oral candidiasis. Parotid gland enlargement is typically an early manifestation in HIV, and oral or oesophageal candidiasis is a particular hallmark of later stage HIV/AIDS in children[13].

Unusually persistent infections which require multiple courses of antibiotics, or the need for prolonged periods of intravenous antibiotics should also prompt consideration of an underlying immunodeficiency.

Severe infections

More severe primary immunodeficiencies may present early in infancy with potentially life-threatening infections, including of the ENT system. In these cases, patients will often have many systems involved which should help prompt for further investigation into an underlying disorder. Severe combined immunodeficiency (SCID) phenotypes are rare, but early diagnosis improves outcome. They tend to present early in life, within the first month 3-6 months[14] and systemic signs include failure to thrive, chronic diarrhoea and candidiasis[15].

Opportunistic or unusual infections

Infections with unusual organisms should always prompt further investigation. Although uncommon presentations of common diseases are more common than an uncommon disease, investigation should start early as the underlying condition could be life threatening[16].

Organisms which should attract special attention include *Pseudomonas aeruginosa*, which is often a hallmark of genetic respiratory conditions such a cystic fibrosis or primary ciliary dyskinesia which have defects of innate immune barriers. Candidiasis of the mucous membranes of the upper respiratory tract should prompt consideration of HIV[17], or less commonly chronic mucocutaneous candidiasis. Other organisms which may infect the upper respiratory tract which should prompt consideration of HIV or other T lymphocyte deficiencies include *Pneumocystis jivoreci/carinii* and *Mycobacterium tuberculosis*[15]. Fungal infections with *Aspergillus spp* or *Candida spp* may also be presenting features of a defect of phagocyte function (e.g CGD)[18]. Recurrent otitis media and sinusitis with encapsulated bacteria such as *Neisseria meningitidis* may be the presenting feature of a complement deficiency[19].

Investigation of suspected immunodeficiency

Once suspicion has been raised about the possibility of an underlying immunodeficiency, a stratified approach to investigation can be put in place. There are some simple first steps which can be taken by anyone suspecting an immunodeficiency in a child such as a full blood count and differential, basic immunoglobulins (IgG, M and A) and sweat test for cystic fibrosis, prior to referral to specialists in children's immunology and infectious diseases, or respiratory medicine (depending on the clinical presentation). Referral should be made urgently, or if the degree of suspicion is high or there are immediate concerns about the severity of the presentation.

An approach to screening for immunodeficiencies is shown in Table 3[16]. Clinicians should be aware that some low cell counts can be normal under certain circumstances. For example, a transient neutropenia or lymphopenia in isolation can be normal in children following a viral illness. An incidental neutropenia does not need to be repeated if there are no underlying concerns about immunodeficiency. Persistent lymphopenia in a child under 2 years old should prompt screening for SCID[20].

Management of children with immunodeficiency in the Ear, Nose and Throat clinic

Special considerations should be made when managing patients with underlying immunodeficiency, and management will usually be in conjunction with paediatric immunology and infectious diseases, or respiratory medicine, specialists.

Treatment of underlying disorder

In some immune disorders it is possible to treat the underlying pathology, either by specific immune therapies such as substrate replacement or targeted molecular therapies, or by treating the cause of secondary immunodeficiency.

Table 3: Investigations for suspected immunodeficiency

Clinical Presentation	Suspected disorders	Investigations
Recurrent ENT or airway infections	a) Physiological immunodeficiency of infancy b) Antibody deficiency (XLA), CVID, Complement deficiency	Initially FBC (+differential), IgG, IgM, IgA If normal, wait 3-6m and see if condition improves If prolonged/unusual history referral for consideration of further tests including vaccine responses (including responses to protein, polysaccharide and specific conjugate vaccine serotypes; and lymphocyte subsets)
Recurrent pyogenic infections	Phagocyte disorders (CGD, Neutropenia)	Initially FBC (+differential) Consider performing just prior to fever episode if cyclical infections/fever (seek specialist input to test at correct point in cycle to avoid multiple tests) Referral for consideration of complement deficiency, absent/non-functioning spleen, single gene defects in innate immune pathways etc.
Severe or unusual infections	T lymphocyte deficiency, HIV/AIDS	Refer early. FBC (+differential), IgG, IgM, IgA, lymphocyte subpopulations (T, B, NK cell profile), HIV test

Humoral deficiencies such as XLA or CVID are managed with immunoglobulin replacement therapy, most commonly now given to children via weekly or biweekly subcutaneous route injections although some children and families prefer intravenous therapy. This is effective in reducing the incidence of acute sino-pulmonary infections in these children, but does not stop them completely[21].

Highly active antiretroviral therapy (HAART) has transformed HIV from a severe life-threatening illness into a chronic one. Children with HIV who are successfully treated can expect to have few complications of the disease in childhood and adolescence unless there are drug adherence issues[22]. Consideration must be made to interactions between their HAART and any antimicrobial therapy required, in particular antifungals[23].

Children with CGD receive prophylactic antibiotics and antifungals, although bone marrow transplant is now an effective and potentially curative treatment. Early bone marrow transplant is also the only current treatment option for SCID[24] although gene therapy trials are currently also in progress for some forms of the disease

Preventative therapy

Prophylactic antibiotics are commonly prescribed for children with physiological immunodeficiency of infancy and childhood although there is little formal evidence for their use or of the potential risks of generating antimicrobial resistance. Prophylactic antibiotics are well-established in the formal treatment of children and adults with primary immunodeficiencies. However, there is considerable variation globally of treatment regimens, reflecting the lack of formal evidence available. Use of a single agent (amoxicillin or cotrimoxazole) is recommended to treat recurrent infections based on evidence in immunocompetent children[25,26]. The macrolide antibiotic azithromycin is also commonly used as the dosing regimen allows children to only have antibiotics once a day for three consecutive days of the week. Cotrimoxazole can be an effective choice for preventing recurrent upper and lower respiratory infections in conditions including CGD and HIV[27,28]. Clinicians should make sure appropriate samples are taken from any sample (such as ear discharge) for microscopy and culture if possible, prior to initiation of any prophylactic regime, or if breakthrough infections occur.

Immunisations play a vital role in preventative therapy for many patients with immunodeficiency, however in certain conditions the efficacy may be limited. In general, annual influenza immunisation is recommended and should be prescribed according to current national guidelines. Additional doses of meningococcal or conjugate pneumococcal vaccines may be recommended, and depending on the underlying disorder, age of the child and laboratory testing some or all live vaccines may be contraindicated. Additional vaccines, or advice regarding the national schedule vaccines will usually be provided by a paediatric immunology and infectious disease specialist.

Treatment of infections

Very little specific literature exists on the treatment of infections affecting the ear, nose and throat in children with immune dysfunction. Various factors need to be taken into consideration, including;

- The patients underlying immunodeficiency – particularly if starting empirical treatment and patient known to be susceptible to particular organisms (e.g *Neiserria meningitidis* in complement deficiency)
- Chronicity of infection and possible presence of biofilms – surgical management may be considered at an earlier stage
- Organisms involved and their sensitivities – older patients may well have been exposed to multiple courses of antibiotics, or long-term prophylactic antibiotics, and so may be more likely to harbour multi-resistant organisms

General principles of management in high risk children include;

- Infections should be treated much more aggressively and earlier than would be considered in the general population
- There should be a lower threshold for high dose and intravenous therapy in the initial phases of treatment, and longer duration of treatment may be necessary
- Aggressive surgical management may be needed in certain circumstances, for example tympanostomy tubes for chronic otitis media in complement deficiency, early bilateral myringotomies in recurrent otitis media in HIV, and early incision and drainage of collections in CGD[29].

Conclusion

Although immune dysfunction is uncommon in children, it is important for otorhinolaryngologists to be aware of its manifestations as children may well present initially with recurrent or severe infections of the upper airways. Whilst most children will not have an underlying immunodeficiency, some basic investigations and consideration of discussion with a paediatric immunologist may be warranted as early diagnosis can improves outcomes for children with confirmed primary

immunodeficiency disorders. Further evidence is needed to guide the prevention and management of infections, especially in children without proven primary immunodeficiency but who suffer from recurrent upper and/or lower respiratory tract infections.

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Laryngeal clefts

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Abstract

Paediatric laryngotracheal clefts are rare congenital abnormalities characterised by failure of fusion of the posterior cricoid lamina and tracheo-oesophageal septum. This leads to an abnormal communication between the larynx, trachea, hypopharynx and oesophagus. Four types of laryngotracheal clefts are classically described ranging from defects in the interarytenoid musculature through to complete absence of the entire trachea-oesophageal septum. Children may present with recurrent coughing, choking episodes, chest infections, airway and respiratory compromise. Management may be complicated due to co-existent morbidities particularly when more extensive laryngeal clefts are present. This article outlines the presentation and the multidisciplinary management of laryngeal clefts.

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Key words
laryngeal, clefts, multidisciplinary, children

Introduction

The incidence of laryngotracheal cleft is reported to be approximately 1% of congenital laryngeal abnormalities[1-2]. First described by Richter in 1792, laryngotracheal clefts range from defects in the interarytenoid musculature through to a complete absence of the entire tracheo-oesophageal septum[3].

Whilst many classification systems exist, that described by Benjamin and Inglis (figure 1) is most commonly referred to today[4]. Sandu et al modified this in 2006 to include the Type 0 (submucous) cleft and to create the subdivisions 'a' and 'b' for the type III cleft[5].

The submucous cleft is characterised by a cartilaginous defect with intact soft tissues (mucosa and interarytenoid musculature)[6].

Type I Laryngeal clefts

Type I laryngeal clefts involve a defect in the interarytenoid musculature without any extension below the level of the vocal cords or through the posterior cricoid lamina (figure 2). It is thought that 20% of type I laryngeal clefts are diagnosed as an incidental finding at surgery and do not cause symptoms. These can be referred to as a deep interarytenoid groove rather than a type I laryngeal cleft[7]. However, more commonly, type I laryngeal clefts produce a heterogenous group of airway and swallowing related symptoms. Airway symptoms include a hoarse voice and inspiratory stridor. Swallowing symptoms are more common and often patients or their families describe coughing, spluttering or choking with feeding/drinking, a persistent cough, or recurrent chest infections[8-10].

Children with these defects may also have a number of other associated medical conditions and it has been thought this may encompass over 50% of those diagnosed[8-10]. These may be common problems such as gastro-oesophageal reflux disease (GORD) or laryngomalacia or less common conditions such as subglottic stenosis or a tracheo-oesophageal fistula (TOF). A number of rarer congenital syndromes may also be associated with laryngeal clefts such as Opitz-Friars/ G Syndrome, Pallister-Hall Syndrome and VACTERL association (vertebral defects, anal atresia, cardiac defects, tracheo-oesophageal fistula, renal anomalies, and limb abnormalities. Children with VACTERL typically present with three of these features). This means that children diagnosed with type I laryngeal clefts may have a vast range of associated medical and psychological comorbidities all of which may alter their swallowing mechanism, influence the benefit of surgery and affect their subsequent rehabilitation therapy.

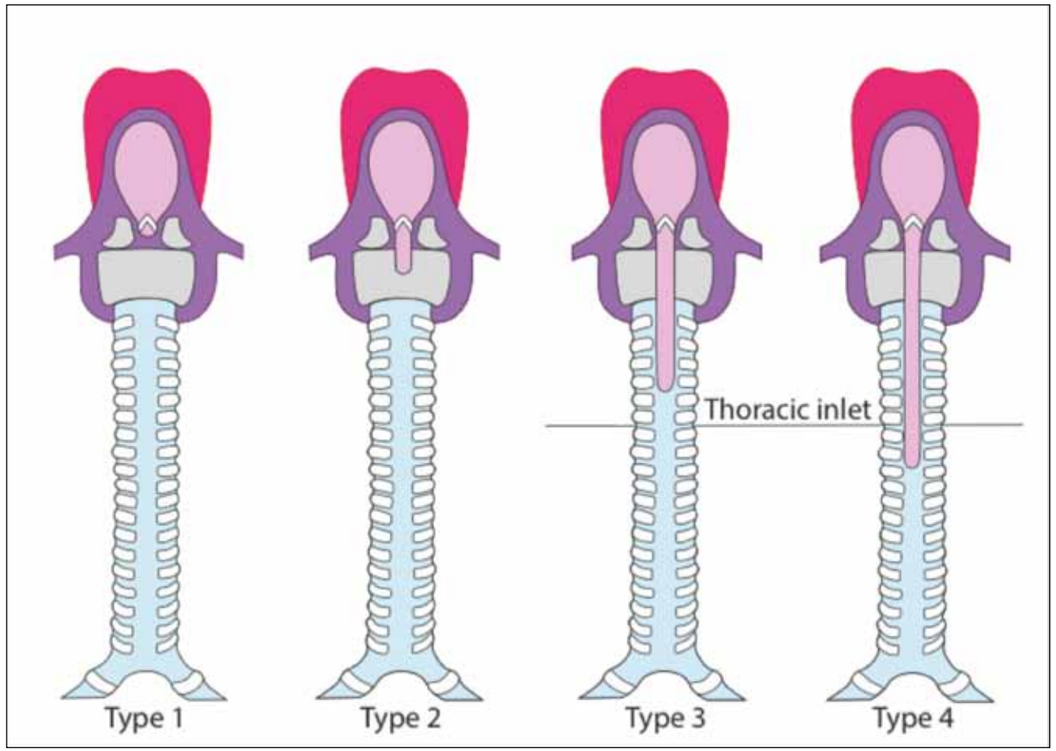

Figure 1: *The Benjamin and Inglis classification system for laryngotracheal clefts[4]. This depicts the four types of laryngotracheal clefts. Type 1 refers to a defect in the interarytenoid musculature, extending to the level of the vocal cords but not through the cricoid; type 2 extend partially through the cricoid cartilage; type 3 extend through the cricoid cartilage into the posterior trachea; type 4 extend into the thoracic trachea up to and sometimes including the carina.*

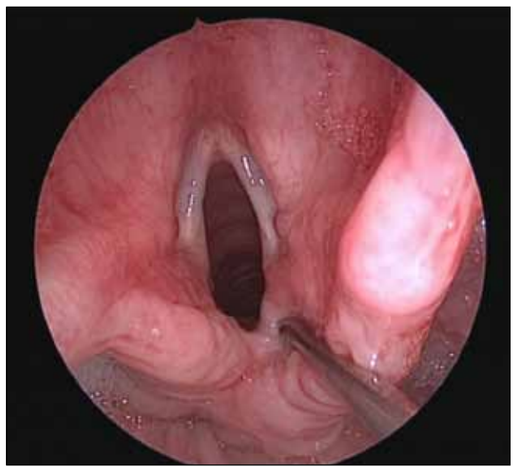

Figure 2: *An endoscopic view of a type 1 laryngeal cleft showing the defect extending to the level of the vocal cords.*

The diagnosis of a laryngeal cleft is made under direct visualisation during a microlaryngoscopy and bronchoscopy (MLB). Laryngeal clefts are not uncommonly missed during inspection of the airway and so it is important to palpate the posterior cricoid and interarytenoid area using a laryngeal probe or right angled hook. This is especially true of the submucous type cleft, which may easily be missed on inspection. A videofluoroscopy (VF) is performed to assess whether the defect in the interarytenoid area causes aspiration and penetration into the larynx. Initial management of patients diagnosed with a type I laryngeal cleft would be a trial of conservative therapy with the involvement of a speech and language therapist[11-13]. This includes prescribing a proton pump inhibitor to minimise gastro-oesophageal reflux, the use of thickened feeds and a variety of feeding positions (upright or head turned) and slow feeding with multiple breaks to minimise aspiration. In some high-risk cases feeding may be stopped orally and the use of an enteral tube is commenced.

Children who fail conservative measures or those with severe symptoms (stridor with respiratory compromise or recurrent chest infections requiring enteral tube feeding) will need surgery with the aim of repairing the cleft and in doing so treating symptoms and helping establish normal feeding patterns.

In the UK and worldwide the method of repair for type 1 laryngeal clefts is endoscopic[11-14]. A microlaryngoscopy and bronchoscopy is performed with the child in a supine position with the neck extended, utilising a shoulder roll and head ring. This is initially undertaken using an anaesthetic laryngoscope and a zero degree Hopkins rod (endoscope). Direct visualisation and inspection of the entire airway is performed to assess the laryngeal cleft and rule out other co-existent airway pathology. Subsequently the larynx is then better visualised for surgery by inserting an appropriately sized Lindholm laryngoscope and placing the child in suspension. Vocal cord retractors are used to optimize the view of the cleft and allow more accurate assessment of its extent. Local anaesthetic is infiltrated into the mucosal margins of the cleft, which are then denuded using cold steel microlaryngoscopy instruments. Absorbable interrupted sutures (5/0) are then placed on the laryngeal and pharyngeal sides of the posterior larynx to form a two-layered closure (Figure 3). The aryepiglottic folds are routinely divided at the end of the procedure. Successful single-layered closure using a mattress suture has also been described. Post-operatively the normal pre-operative feeding regimen is recommenced along with high dose antireflux therapy. A post-operative videofluoroscopy is performed at 4-6 weeks. An MLB may also be performed to directly visualise the repair depending on post-operative symptoms and the VF results.

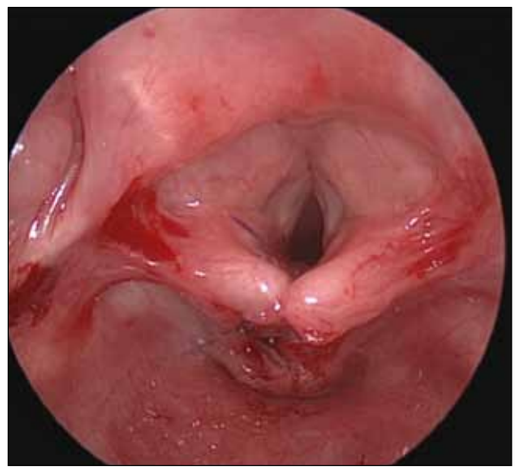

Figure 3: *An endoscopic view of a repaired type 1 laryngeal cleft; sutures visible on pharyngeal and laryngeal surfaces.*

Type II Laryngeal clefts

Type II laryngeal clefts extend inferiorly, partially but not completely through the posterior cricoid lamina. Similarly to type I laryngeal clefts, they present with a combination of airway compromise, voice disturbance and swallow dysfunction. The diagnosis can be confused with asthma due to common symptoms of a chronic cough and wheeze. Diagnosis is based on a high index of suspicion especially if the child has other known associated disease or one of the syndromes reported earlier. A referral to the speech and language therapists and subsequent videofluoroscopy will provide information on the severity of aspiration and also allow for the introduction of conservative measures such as dietary modification, thickened feeds and management of gastro-oesophageal reflux to commence. However type II laryngeal clefts almost always will require surgical intervention.

Children with severe and recurrent aspiration pneumonias, worsening pulmonary function or airway symptoms need early surgical repair. This is carried out endoscopically in a similar fashion to that performed for type I laryngeal clefts unless coexisting pathology such as subglottic stenosis favours an open approach.

The outcomes of endoscopically repaired type I clefts have been reported as showing an 80% improvement in postoperative swallow and cough and while type II clefts are less commonly reported, there are reviews indicating an 70% improvement in the same symptoms with minimal comorbidity[11,12,15-18]. Syndromic patients and those requiring enteral feeding have a poorer outcome and residual respiratory symptoms can be related to a number of factors.

It is important to remember that each patient diagnosed with a type I or II laryngeal cleft is unique and the severity of underlying pulmonary dysfunction from recurrent aspiration, microaspiration, concurrent neurological comorbidity and gastro-oesophageal reflux is often unknown. As such each child is managed on a case-by-case basis, assessing and optimising any co-existent medical issues with the multidisciplinary multiprofessional team.

Type III and IV Laryngeal clefts

Type III and Type IV laryngeal clefts are anatomically, functionally and prognostically a more challenging group of patients and their management should be undertaken in a tertiary paediatric airway centre with experience in managing children with laryngeal clefts.

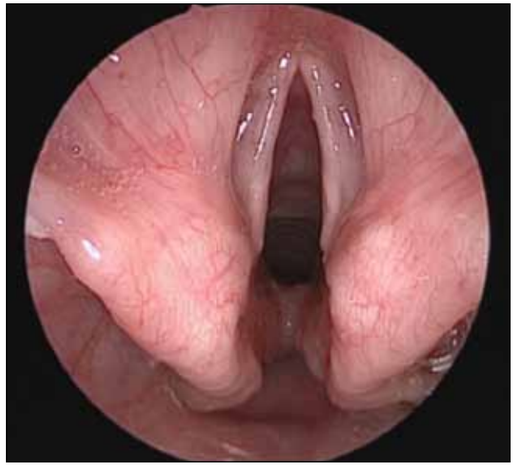

Figure 4: *An endoscopic view of a type III laryngeal cleft.*

Anatomically a type IIIa laryngeal cleft extends through the cricoid but not into the extrathoracic trachea while a type IIIb passes into the extrathoracic trachea (figure 4, 5). Type IV laryngeal clefts, which are exceedingly rare, extend into the intrathroacic trachea (figure 6). As one would expect the morbidity and mortality of intrathoracic clefts is much higher when compared with extrathoracic clefts and a multidisciplinary approach is essential.

A type IV cleft which extends as far as the carina has an extremely high mortality rate with almost all being unable to be addressed surgically.

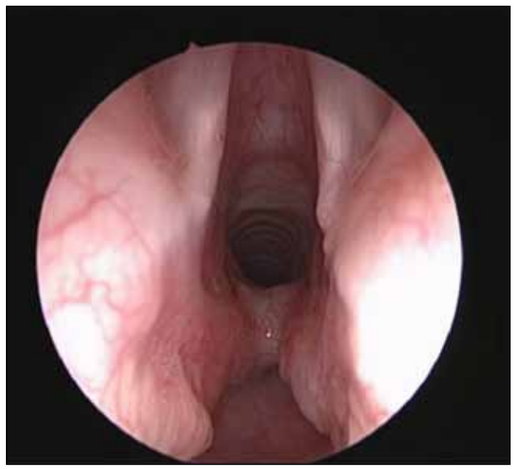

Figure 5: *Type III laryngeal cleft showing the deficient posterior cricoid lamina and tracheo-oesophageal septum.*

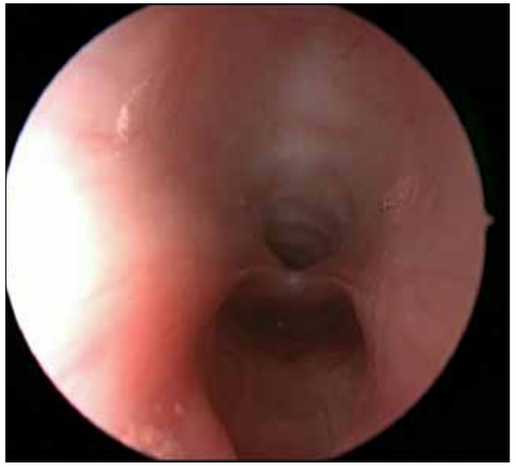

Figure 6: *An endoscopic picture of a type IV cleft extending to the intrathoracic trachea.*

Children with type III and IV laryngeal clefts typically present at birth with significant aspiration and respiratory compromise. Medically their feeding should be managed initially with a nasogastric tube. Prior to surgical repair it is vital that coexisting reflux should be controlled with high dose medication and gastric fundoplication. A gastrostomy may need to be considered as any degree of reflux or the presence of a nasogastric tube can compromise any anastomosis.

While it may be possible to repair a short type IIIa cleft endoscopically, generally surgery for type III and type IV laryngeal clefts is performed via an open approach using an extended laryngofissure to access the cleft. A cervical approach is now considered appropriate in the majority of cases though combined cervical and thoracic approaches have been described for type IV cases. The method of delivery of anaesthesia can vary according to the surgeon and paediatric unit. Both cardiopulmonary bypass and extracorporeal membrane oxygenation have been described for type IV repairs while for type III a low tracheostomy has been traditionally employed to deliver anaesthesia and to support respiration post-operatively. However surgery for extrathoracic clefts can be performed either with a temporary perioperative tracheotomy or with the use of an endotracheal tube placed at the inferior end of the laryngofisssure. The patient is then intubated via a nasotracheal tube post-operatively (with the temporary tracheostomy removed) and extubated when appropriate. Surgical repair at Great Ormond Street Hospital takes place via a two-layer approach with trimming of the excess tracheal and oesophageal mucosa. Many groups describe a third interposition graft layer with tibial periosteum or temporalis fascia to support the two mucosal surfaces and help prevent potential late breakdown of the cleft.

One of the biggest challenges to extubation and respiration post-operatively is tracheomalacia at the site of the repair, which despite successful repair of the cleft may cause significant respiratory compromise. Tracheomalacia can be controlled in part with trimming of the excess tracheal and oesophaegal mucosa. It may also require the use of non-invasive ventilation such as nasal optiflow or continuous positive airway pressure (CPAP), ventilation via the tracheostomy if in situ or in some cases an aortopexy.

Conclusion

Paediatric laryngeal clefts present with an extremely interesting range of pathology from a mild, self-limiting type 1 cleft or an incidental deep interarytenoid groove to a life threatening carinal cleft. As our understanding increases, particularly of type I cases, there is a higher index of suspicion and a more thorough airway examination is leading to increased diagnosis. Enhanced surgical and anaesthetic techniques also will result in improved survival rates for those with more complex type III and IV clefts. A multidisciplinary team approach to management and liaison or transfer to a unit with considerable airway experience as required is recommended.

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Clinical law: Treating children

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Abstract
From the English legal perspective, a child is someone who has not yet reached 18 years of age. Legal synonyms include 'minor' and 'infant'. The latter is instructive, since it is derived from the Latin noun: ***Infans***, meaning ***unable to speak***. This reflects the legal rules which prevent children from speaking for themselves in court, although this impediment has been at least partly addressed over the last two decades. Nevertheless, it begs a fundamental question, as to whether children can provide their own consent, or whether they depend upon their parents to provide it for them.

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Key words
Consent, law, children

Nomenclature.
It is conventional[1] to describe 16 & 17 year olds as young people, and those younger as *children*. Equally, to describe the capability to make valid treatment decisions as *competence* in children, and *capacity* in young people.

People under 18 years can thus be considered in three broad groups.

Children lacking competence
This is the simplest group. Although presumed to lack competence, some will be able to demonstrate their capability to provide independent consent for treatment (*see below*).

For those who cannot, a person with parental responsibility has the right to provide consent where necessary. The child's mother (the woman who gave birth to the baby, rather than the person who provided the egg from which he was conceived, if different) automatically has parental responsibility. The child's father gains parental responsibility automatically if married at the time of the birth registration. Since 2003, unmarried fathers also get parental responsibility automatically by ensuring the birth is registered in their name. Alternatively, parental responsibility can be acquired by the unmarried father, either with the agreement of the child's mother, or by application to a court.Parental responsibility is passed to adoptive parents on legal adoption. It may be shared with guardians appointed by parents; with local authorities; and is linked to various legal orders[2].

The person with parental responsibility who provides consent for a child's surgery must act in the child's best interests in so doing. These are usually self evident, and the agreement between parents and surgeon is reached after full disclosure of the relevant information[3].

This agreement is not invariable. In a case[4] concerning a child with biliary atresia, the clinicians wished to perform a liver transplant, and considered the prospects of success to be good. The parents refused their consent, on the grounds that the surgery was not in the child's best interests. The Court of Appeal held that the assessment of the child's best interests went wider than the narrower medical best interests, and that T's connection with his family held great weight in this regard. Accordingly, the court refused to enforce the hospital's request that the mother would bring T in for surgery. The judgement could be criticised, failing to differentiate between the interests of the child and those of his mother. However, the case provides an example of the balancing act performed by courts.

This balancing act has been challenged in 2018, with the Gard[5], Haastrup[6] and Evans[7] litigations all seeking court guidance on the role of strongly held parental views that life prolonging treatment should be continued. This question was answered in plain language in the latter case. The sole principle being that the best interests of the child must prevail, and that this must apply even to cases where parents, for the best of motives, hold on to some alternative view. Parents are not entitled to insist upon a treatment which is counter to their child's best interests. In cases of conflicts between the child interests and those of her parents, to reiterate, the child's interests must prevail.

Children who can demonstrate their competence
Depending on their maturity and the intervention that is proposed, children from a young age may be able to provide independent consent. A four year old may be able to consent to a blood pressure measurement; a six year old to a venepuncture; a 12 year old to the removal of an early stage appendicitis. No-one is suggesting that the parents should be excluded from this process; such exclusion would be quite wrong. It is for the family as a whole to decide what part the child's potential competence should play in the consenting process. But the involvement of children in this process will strengthen the therapeutic relationship, and is to be encouraged.

A child's previous experience is of great importance. It is submitted that following the very recent diagnosis of leukaemia, a 15 year old, who has been healthy up to this point, will be so horrified by the dissolution of his comfortable and well organised life as to be rendered incoherent, entirely incapable of consenting for the necessary tunnelled central venous catheter (CVC). Contrast this child with a 10 year old on the same ward; suffering relapsed leukaemia. He has already undergone three line insertions and removals. He knows (effectively) everything there is to know about CVC placement, complications and disadvantages. Now facing his fourth insertion, he will very likely be competent to provide independent consent.

Therefore, it is important objectively to determine whether a child of 15 years or younger is competent to provide independent consent for the proposed intervention.

For this assessment, the *Gillick* test is used; derived from a landmark case where it was established that a child competent to provide consent should be allowed to do so, independently of her parents. The test requires that the child has sufficient understanding and intelligence to enable them to understand fully what is involved in a proposed intervention[8]. Thus, if a child can understand:

- That a choice exists
- The nature and purpose of the procedure
- The risks and side effects
- The alternatives to the procedure; and is able:
    - To retain the information long enough…
    - To weigh the information…
    - To arrive at a decision
    - *And* to be free from undue pressure

Then she would be deemed competent for the proposed intervention. It will be seen that competence rests on intelligence, maturity and experience. Not on age.

During the *Gillick* case, an additional set of guidelines were suggested by Lord Fraser, specifically for doctors who assist with reproductive decision-making by children below 16 years. It should be noted that these do not replace the *Gillick* test, nor are they synonymous with it[9].

Gillick provides a high threshold for consent, consistent with public policy. It would be highly undesirable to allow incompetent children to provide consent for interventions which they could not fully understand. The fact that a child has to 'prove' their competence places a barrier to children that is never experienced by adults, whose capacity is presumed. One can only speculate how many adults would 'pass' the test in *Gillick*.

The competent child does not enjoy an equal right to refuse treatment. Only those cases in which the refusal of life- saving treatments in these children is at issue have reached the court. But given this opportunity, courts have resolutely denied the (otherwise) competent minor the right to choose death. A 15 year old girl[10] refusing her consent for a life-saving heart transplant had her refusal overridden by the courts. M's reason was that she 'would rather die than have the transplant and have someone else's heart…I would feel different with someone else's heart… that's a good enough reason not to have a heart transplant, even if it saved my life….

The court authorised the operation, as being in her best interests.

In another case[11], a 14 year old girl with serious scalding required a blood transfusion. She was a Jehovah's Witness, and refused the treatment. The court found that even if she had been *Gillick* competent, her grave condition would have led the court to authorise the transfusion. As it was, the girl was unaware of the manner of death from anaemia, and was basing her views of on those of her congregation, rather than on her own experiences. For these reasons, she was judged incompetent to make this decision for herself.

It must be remembered that the vast majority of competent children who refuse treatment are refusing relatively trivial procedures. You would be entitled to rely upon their parent's consent if necessary, but it is a matter for clinical judgement whether the procedure could be deferred, to allow the child further time to consider, and be reconciled with what is likely to be an inevitable outcome. The problem of refusal in competent children is dealt with in the same way as for the 16 & 17 year age group, below.

Young People

People of 16 & 17 years of age are presumed to have the capacity to provide consent for surgical, medical and dental treatment. This was made possible by a law enacted in 1969[12], which recognised that the decisions that teenagers were taking, irrespective of the law, contrasted sharply with the age of majority (21 years) at the time. The new law reduced the age of majority to 18 years, and introduced the presumption of capacity for 16 & 17 years olds. In 2007, a wide-ranging statute[13] addressing mentally incapacitated adults (counter-intuitively named the Mental Capacity Act) was introduced, including many provisions applicable to young people.

The existing framework does not extend to a statutory right for a young person to provide consent for research independent of her parents, or interventions that do not potentially provide direct health benefit to the individual concerned. However, if capacitious along '*Gillick*' lines, a young person may arguably be able to provide consent for these activities.

Young people are nonetheless able to provide consent for treatment in absence of their parents. However, the parental right to provide consent for treatment lasts until the end of childhood. This has the effect of providing a 'safety net'; allowing a 16/17 year old the opportunity of consent for herself; or deferring to her parents, if she sees fit. Once the child reaches adulthood on her 18th birthday, her parents' right disappears. For the rest of her life, she alone can provide consent, either in person; or in some circumstances, by a proxy method.

If parents and a child of this age disagree, it is wise to exercise caution

If a young person wishes to exercise his right to consent, and his parents oppose the decision, then you would be entitled to rely on this consent. However, it would be important to understand the basis for their disagreement. For instance, if you suspected that the patient lacked capacity, you should challenge the presumption. This can simply be done by establishing whether he understands the relevant information; can retain the information, believe it, weigh it up….and communicate his decision. If he can, then he has capacity. But it is still wise to tease out where the problem lies, since this is a most unusual situation, and it would be in the young person's best interests to resolve the issue before surgery, if that is feasible.

The problem, reversed, is of a young person who refuses treatment, but who is accompanied by a parent who provides consent. Valid parental consent will make the procedure 'legal', but as with the situation of consent withdrawal, you will have to make a clinical judgement as to whether proceeding with the treatment against the young person's wishes is both practicable, and in her best interests.

The parental right in reality diminishes during the period of the 16th and 17th year, and this is reflected in the doctrine of the *scope* or *zone* of parental responsibility, a phrase originally emerging from (and still largely residing within) adolescent psychiatry, particularly with respect to parental consent to their child's compulsory detention. Since 2007[14], doctors have been advised not to rely on parental consent for the voluntary admission and treatment of a young person for mental illness, if their offspring is refusing the voluntary admission. The alternative of compulsory admission under the Act is sometimes preferred.

Conclusion

In summary, returning to the world of surgery, it is recommended that an elective procedure should be abandoned until the dispute is resolved. If emergency treatment is required, but could be administered in a different way which was still consistent with the refusing patient's best interests, the alternative should be explored. If her life or limb is threatened, and there is no choice but to provide a definitive operation, then reluctantly, you may feel the need to restrain the patient and proceed. A planned semi-elective tracheostomy in a patient whose supraglottic airway state is deteriorating into an emergency in front of you could be an example of this situation. It should be noted that in reality, the amount of resistance that a child of any age puts up is usually inversely proportional to their malaise and discomfort. In the gravely ill, refusal is rare.

There are those who are gravely ill, but needing urgent rather than emergency treatment. If a 16/17 year old in this category refuses treatment for the preservation of her life, such as the transfusion of blood[15], or feeding[16] (in anorexia), courts invariably choose to override the child's autonomy, and provide an order which allows lawful provision of the treatment against the child's wishes. This either upholds the parental wishes for treatment, or overrides parental refusal. These cases are rare, but the timescale within which the decision needs to be made allows sufficient time for the court to be contacted, providing the surgeon with the necessary authority.

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Paediatric gastroesophageal reflux disease

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Abstract
Gastroesophageal reflux (GOR) is common in infants and children. Distinguishing Gastroesophageal reflux disease (GORD) from GOR is challenging due to the frequency and range of symptoms, the range of impact on family functioning, and the communication issues, especially in young children. Lack of a single, easily doable, sensitive and specific diagnostic test, makes the diagnosis harder. Gastroesophageal reflux and GORD may contribute to other conditions managed in the paediatric population by Ear, Nose and Throat (ENT) surgeons. This review discusses the presentation, investigation and management of paediatric GOR and GORD.

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Key words
gastroesophageal, reflux, paediatric, children

Definitions
The National Institute for Health and Care Excellence (NICE) defines Gastroesophageal reflux (GOR) and Gastroesophageal reflux disease (GORD) as follows[1,2]:

- GOR is passage of gastric contents into the oesophagus. It is a common physiological event that can happen at all ages (but is more frequent in infants) and is often asymptomatic.
- GORD is GOR that causes symptoms (for example, discomfort or pain) severe enough to merit medical treatment or that has associated complications (such as oesophagitis or pulmonary aspiration). Pathologic reflux or GORD is easier to diagnose in children presenting with any of the red flag symptoms (table 1) including symptoms such as haematemesis or growth failure. In the absence of these symptoms GORD may also be diagnosed by reported significant 'discomfort' or 'pain'. These symptoms are subjective and affected by communication issues in paediatric patients and the degree of parental concern. It should be borne in mind that at least one third of otherwise healthy babies cry for more than three hours a day.

Epidemiology
GOR is common in infants. There is high prevalence of overt regurgitation in infants less than 3 months of age and the incidence is reported to be as high as 50%[3,4]. This improves in the first year of life such that at one year less than 5% of infants have symptomatic GOR[4]. Pharmacological treatments such as proton pump inhibitors (PPI) or Ranitidine confer little benefit.

GOR/GORD in the older child and adolescent is more of an 'adult type', different from reflux in infancy. A nationwide French questionnaire study showed that compared to infants, adolescents are more likely to need pharmacological treatments for symptoms of reflux[5].

This study also showed that reflux was common in children, with GOR present in 10.3% and GORD in 6.2% of children respectively. In another cross-sectional study from Spain, GORD was more commonly found in older female adolescents and children with neurological diagnoses[6].

Overall, the exact prevalence and incidence for GORD remains unknown due to difficulty in defining and differing presentation/ natural history in different paediatric age groups.

Gastroesophageal Reflux disease
Although there is no prescriptive classification, the authors tend to see infants and children with reflux, broadly divided into these three groups:

Table 1: Red flag symptoms suggesting conditions other than GOR in infants and children. Adapted from NICE[2]

Symptoms and signs	Possible diagnostic implications	Suggested actions
Gastrointestinal		
Frequent, forceful (projectile) vomiting	May suggest hypertrophic pyloric stenosis in infants up to two months old	Paediatric surgery referral
Bile-stained (green or yellow-green) vomit	May suggest intestinal obstruction	Paediatric surgery referral
Haematemesis (blood in vomit)	Suggests upper gastrointestinal ulceration, including erosive oesophagitis	Specialist referral for investigation
Onset of regurgitation and/or vomiting after six months old or persisting after one year old	Late onset suggests a cause other than reflux, for example a urinary tract infection Persistence suggests alternative diagnosis	Urine microbiology investigation Specialist referral
Blood in stool	May suggest a variety of conditions, including bacterial gastroenteritis or an acute surgical condition	Stool microbiology investigation Specialist referral
Abdominal distension, Tenderness or palpable mass	May suggest intestinal obstruction or another acute surgical condition	Paediatric surgery referral
Systemic		
Appearing unwell	May suggest infection	Clinical assessment and urine microbiology investigation Specialist referral
Fever	May suggest infection	Clinical assessment and urine microbiology investigation Specialist referral
Dysuria	May suggest urinary tract infection	Clinical assessment and urine microbiology investigation Specialist referral
Bulging fontanelle	May suggest raised intracranial pressure, for example due to meningitis	Specialist referral
Rapidly increasing head circumference (more than 1cm per week)	May suggest raised intracranial pressure, for example due to hydrocephalus or a brain tumour	Specialist referral
Persistent morning headache, and vomiting worse in the morning	May suggest raised intracranial pressure, for example due to hydrocephalus or a brain tumour	Specialist referral
Altered responsiveness, for example, lethargy or irritability	May suggest an illness such as meningitis	Specialist referral
Eczema	May suggest gastrointestinal cow's milk protein allergy	Trial of cow's milk exclusion Specialist referral

Group I. Gastroesophageal Reflux symptoms in young infants
As stated in the epidemiology, this is common and has a good outcome. Infants double their length in the first year of life, with significant motor development (lying to standing position), which further affects the presentation and evolution of reflux making it a somewhat different condition to gastroesophageal reflux in the older child.

Group II. Gastroesophageal Reflux in the older children (teenagers and adolescents)
This type of reflux is similar to the 'adult type' of GOR and GORD. In older children, reflux that persists or is troublesome is much more likely to be clinically significant, especially when there is a history of nighttime waking. Other suggestive symptoms include tasting acid, upper chest burning pain, feeling of food getting stuck and discomfort with swallowing. This is more likely to persist

unless medical treatments are used. Barrett's oesophagitis[7] or oesophageal strictures are reported complications of untreated oesophagitis in children.

Group III. Gastroesophageal Reflux in children of any age with a 'syndrome', another 'systemic diagnosis', 'neurological condition' or any type of abdominal or chest surgery

Certain paediatric populations have a much higher prevalence of GORD, these include

- Children with neuro-disability (approximately 50%)[8]
- Ex-premature babies
- Babies with coexistent respiratory or cardiac issues
- Children with disruption of the normal oesophageal neuroanatomy (for example, children with repaired oesophageal atresia/congenital diaphragmatic hernia)[9]
- Children with genetic conditions such as Russell Silver10 and Noonan's syndrome where pathophysiology is multifactorial and may be related to underlying foregut dysmotility[11].

It's worth mentioning that quite often, this group of children receive polypharmacy by clinicians keen to control symptoms (some prescriptions are for 10-15 medicines used 2-3 times a day amounting to 45-50 doses daily of different medications); the authors (NAA, MT) have often seen GOR secondary to side effects of these treatments. The correct strategy in such cases is 'clinical tailoring' rather than prescribing more treatments (anti-reflux).

Aetiology of GORD

GOR is a common physiological condition in infants that does not require treatment. Some babies are fed more in a parental attempt to control distress, which creates a further cycle of upset, and can exacerbate regurgitation. Overfeeding diagnosed on a 'detailed history' should be addressed prior to attempting medical treatments. An experienced health visitor can play a significantly positive role in the management of GOR in infants and we strongly advise a health visitor referral for assessment, advice and support in such cases.

Sometimes GORD may be secondary to allergy or infection as discussed below.

Cow's milk protein allergy (CMPA/CMPI)

CMPA can present in infants with symptoms of GOR[12]. However, making such a diagnosis can be challenging in an infant and CMPA is overdiagnosed. In an observational study of 2,342 infants, 6.1% of parents of infants reported an adverse reaction to exposure to cow's milk, but on oral testing only 2.7% were actually allergic[13]. Blood testing and skin prick tests (SPTs) have a lower predictive value in infants, compared to children, and some children may have a non-IgE mediated CMPA that responds to a 2 week cow's milk protein (CMP) free diet.

Again, to make a diagnosis an accurate detailed history is essential and CMPA should be considered in the following[14]:

- Presence of family history of allergic disease is suggestive but not diagnostic
- Symptoms affecting multiple organs may be suggestive of allergy, for example, eczema, blood in stools, diarrhoea. This is particularly relevant if infants have not responded to initial 'reflux treatments'
- Worsening symptoms with increased doses of CMP eg switching from breast to bottle feeding or changing from formula to cow's milk

The clinician should have a clear aim and plan before initiating a trial of a CMP-free diet for 2 weeks, or when requesting tests such as blood tests and SPTs for allergies, which should be carefully interpreted in the actual clinical context of the child.

Helicobacter Pylori

Not every child with reflux requires testing for Helicobacter. Helicobacter pylori testing should be considered in areas of high prevalence[15] and in children with symptoms of

- Dyspepsia
- Refractory foregut pain symptoms
- Those with unexplained iron deficiency anaemia particularly when dietary Iron intake is adequate.

Helicobacter is assessed by stool serology (98% sensitive and specific), blood (94-95% sensitive and specific), or on urease breath test. When suspected, family members should also be screened.

Sequelae of GORD

GORD is associated with a number of complications and GOR in association with laryngopharyngeal reflux disease (LRD) and Asthma is discussed below.

Laryngopharyngeal reflux disease (LRD)

LRD is defined by reflux into larynx, oropharynx or pharynx and is pathological. Children with LRD may present with a hoarse voice, chronic cough, laryngomalacia, aspiration and failure to thrive, on the background of symptoms of regurgitation[16].

It is always important to identify the 'source' of the 'aspirate', which could either be related to aspiration secondary to swallowing issues or severe GORD. LRD in the absence of overt gastroesophageal reflux should prompt the clinician to arrange Speech and Language therapy assessment before gastrointestinal (GI) investigations (Table 1).

In cases of recurrent aspiration distinguishing LRD and GORD from asthma can be aided by multidisciplinary assessments and management plans involving paediatric ENT specialists, Respiratory and GI teams. Joint procedures if required can be undertaken avoiding repeat general anaesthetics.

Asthma

Worsening asthma may be related to GORD. The North American Society for Paediatric Gastroenterology, Hepatology and Nutrition (NASPGHAN) guidance[17] identifies 3 groups of children where empirical treatment may be helpful:

- Asthma with symptoms of heartburn
- Nocturnal asthma symptoms
- Steroid dependent difficult to control asthma

An abnormal pH impedance study prior to initiating treatment may be useful however the predictive value of the pH test in this clinical context remains unknown.

Investigations

On reviewing the literature a number of studies looking at lung nodules in the HNC population have now been published. As stated, GORD is a clinical diagnosis. Investigations if needed should be decided in conjunction with a paediatric gastroenterologist or a paediatrician with interest in paediatric gastroenterology.

Combined oesophageal multichannel intraluminal impedance and pH monitoring

The pH study was formerly the gold standard but has now been replaced by combined oesophageal multichannel intraluminal impedance and pH monitoring (MII-pH). The pH probe helps to determine the degree of acid reflux with the impedance allowing detection of the frequency and height of reflux episodes. The British Society of Paediatric Gastroenterology, Hepatology and Nutrition (BSPGHAN)[18] has recently published guidance on its use with indications given in Table 2.

Table 2: Indications for combined pH and impedance investigations[2,18]

Recurrent aspiration pneumonia
Unexplained apneas
Unexplained non-epileptic seizure-like events
Unexplained upper airway inflammation
Dental erosion associated with neurodisability
Frequent otitis media
A possible need for fundoplication
A suspected diagnosis of Sandifer's syndrome

Gastroscopy with multi-level oesophageal biopsies

Gastroscopy[19] helps to identify oesophagitis in children (indications in Table 3) and should preferably be undertaken by a paediatric gastroenterologist. Authors recommend doing 3 level oesophageal biopsies, to look for presence or absence of gradient of inflammation in the oesophagus. Typically, in GOR a higher number of inflammatory cells are seen in the lower oesophageal biopsy compared to the upper biopsy, whereas no gradient may be seen in eosinophilic oesophagitis. Eosinophilic oesophagitis may be secondary to allergy and mucosal IgG4 positivity has recently been reported in association with allergy related eosinophilic oesophagitis[20,21]. Further, multiple level biopsies in addition to the above alongside the correct identification of gastroesophageal junction are required when screening for Barrett's oesophagus.

Barium meal

A barium meal is very useful to define foregut anatomy and diagnose conditions especially malrotation. It is important to assess the position of the Duodenojejunal flexure when looking for malrotation.

Table 3: Indications for performing an endoscopy in GORD[2]

Haematemesis not caused by swallowed blood (assessment to take place on the same day if clinically indicated).
Melaena (black, foul-smelling stool; assessment to take place on the same day if clinically indicated.
Dysphagia (assessment to take place on the same day if clinically indicated).
No improvement in regurgitation after one year of age.
Persistent, faltering growth associated with overt regurgitation.
Unexplained distress in children and young people with communication difficulties.
Retrosternal, epigastric or upper abdominal pain that needs ongoing medical therapy or is refractory to medical therapy.
Feeding aversion and a history of regurgitation.
Unexplained iron-deficiency anaemia.
A suspected diagnosis of Sandifer's syndrome.

Clinicians have historically often used a barium meal to diagnose reflux in children; this is inappropriate. A child may not reflux at the time of the barium meal test but reflux at other times of the day. Conversely, a child who does not like the taste of barium may vomit it and unless performed by an experienced paediatric radiologist may be diagnosed as severe GORD.

Fluoroscopy under Speech and Language therapist guidance

This test is performed by a paediatric radiologist in conjunction with a Speech and Language therapist and is considered where aspiration is suspected. Pooling of contrast in the valleculae, pyriform sinuses and pharyngeal recesses may point towards a swallowing abnormality. Aspiration is diagnosed when the dye tracks down into the larynx and tracheobronchial tree. Videofluoroscopy (VF) would typically be considered in a child where the cause of aspiration is unclear and is often undertaken in a multidisciplinary (MDT) setting with pre-planned GI investigations.

Gastric emptying or Milk scan

The test is based on the principle of administration of a feed consisting of a milk-based meal containing a radiotracer (Technetium-99) hence the name 'milk scan'. The scan is useful to view gastric emptying, reflux[22] and possible aspiration. Importantly there are no validated normal gastric emptying values in children and often T ½ emptying times are extrapolated from adult research studies. Late images may help to diagnose late activity in the lungs suggestive of aspiration.

Bronchoscopy and Laryngoscopy

Bronchoscopy and Laryngoscopy may help to identify LRD, however it is important to understand that this is based on direct visualisation of the mucosa. Usually there are no tissue biopsies taken with these procedures as one does with gastroscopy. Whereas histology results can be standardised, it is well known that visual reports are subject to inter-observer variation[23]. The 'reported' findings therefore need to be interpreted with caution.

Radionuclide Salivagram Single Photon Emission Computed Tomography (SPECT/CT)

Radionuclide salivagram SPECT/CT may help to diagnose aspiration of small amounts of saliva particularly in cases of recurrent chest infections[24].

Treatment

A recent survey of 1,475 paediatric specialist's beliefs about symptoms, diagnosis and treatment of GORD in premature infants showed a general disagreement on nearly all aspects of the management[25]. The difficulty lies in the diagnosis, being essentially clinically based. Variations are likely to occur in relation to personal interpretation and physician experience.

Medical treatments[26,27]

The NICE guidelines[2] recommend a 4-week trial of PPI or H_2 receptor antagonists. This applies to infants and young children and those with neurodisability who may not be able to report symptoms and have one or more of the following:

- Unexplained feeding difficulties (e.g. resisting feeds, gagging or choking)
- Distressed behaviour
- Faltering growth

Alginates and sucralfate are used for the treatment of heartburn on an as required basis. These treatments are not without side effects, for example Gaviscon Infant Powder a popular formulation has sodium content of 0.92 mmol per dose and an infant taking 5-6 feeds would receive 5.5-6.5 mmols of Sodium per day, which may partly account for constipation observed in infants. Intraluminal impedance and pH studies in children fail to highlight a significant difference in reflux after Gaviscon use when compared to Placebo[28].

In children and young people with persistent heartburn, retrosternal or epigastric pain and endoscopically proven oesophagitis, there is good evidence that a PPI is efficacious. Ranitidine is the commonly used H^2 antagonist that reduces basal and mealtime acid production and pepsin secretion. PPI's such as omeprazole, lansoprazole, esomeprazole, pantoprazole, rabeprazole etc. constitute a group of drugs that reversibly inactivate H+/K+-ATPase - the parietal cell membrane transporter. This action increases the pH of gastric contents and decreases the total volume of gastric secretion, thus facilitating emptying. Liquid omeprazole preparation is expensive and this unlicensed 'special formulation' doesn't taste great (due to bicarbonate), but should be considered in children with gastrostomy and jejunal tubes.

Despite the commonly held belief that PPIs and ranitidine are safe treatments, these medications have side effects, as seen in 23% of children treated with H^2 blockers and 34% of children treated with PPIs. These include headaches, diarrhoea, nausea and constipation[29]. The authors (NAA, MT) have also encountered some rarer side effects including allergic rashes, alopecia and lethargy in their practices. More recently population based studies in adults report osteoporosis and gastric cancer[30]. At this point, there is no evidence of those side effects in children.

Prescription and usage of these medications always requires careful consideration.

The Medicines and Healthcare Products Regulatory Agency (MHRA) warning regarding Domperidone

Domperidone is a dopamine-receptor blocker that acts not only peripherally but also centrally, blocking chemoreceptor trigger zone (CTZ) receptors. There is moderate evidence of absence of efficacy for domperidone for treatment of GOR and despite this until recent times, domperidone has been commonly used in clinical practice as part of empirical medical therapy for GORD. In 2015 the MHRA raised concerns regarding prolongation of the QT interval (QTc) with the risk of cardiac side effects. Case reports have also described extrapyramidal side effects with Domperidone use[31,32].

Lack of response to treatment, other feeding modalities and surgery

Lack of response or initial response with subsequent recurrence of symptoms warrants a referral to paediatric gastroenterologist for further investigations. Jejunal feeding, endoscopic gastroplication[33,34] and fundoplication are considerations in severe persistent GORD and are beyond the scope of this article.

Conclusion

GOR and GORD are clinically based diagnoses and require a detailed clinical assessment for diagnosis. The outcome in infants is excellent and is different from GORD seen in the teenager. Early treatment should be considered in the vulnerable high-risk group with rationalisation of polypharmacy where possible. Trial treatments may be prescribed as per NICE guidance and if there is any doubt with regards to the diagnosis a referral should be made to the paediatrician. Investigations for GORD should be decided in conjunction with a paediatric gastroenterologist or a specialist paediatrician who has an interest in paediatric gastroenterology.

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Assessment and management of pediatric dysphonia

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Abstract
Introduction: Voice disorders affecting the pediatric population are common and complex. Treating clinicians must understand the anatomical changes occurring in the growing larynx, as well as the adjunct psychosocial ramifications related to these disorders. Clinicians must tailor practices commonly used on adult patients and adopt a specialized algorithm for managing these challenging and impactful conditions in children.

Methods: Review of the literature and discussion of clinical recommendations for assessment and management of common pediatric voice disorders.

Results: Specific challenges to as well as recommendations for evaluation and treatment of common phonotraumatic disorders in children are discussed.

Conclusion: Management of pediatric voice disorders differs from that in the adult counterpart and is optimized through specialized knowledge of pediatric anatomy and experience treating dysphonic conditions in children.

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Key words
Pediatric dysphonia, pediatric voice disorders, phonotrauma, vocal fold nodules

Introduction
Disorders of the pediatric voice are widespread, with prevalence rates cited as high as 38% in the pediatric population[1,2] impacting 1 million children in the United States alone.[3] Etiologies of pediatric voice disorders are multifarious, and include congenital, inflammatory, infectious, and phonotraumatic causes. Vocal fold nodules are a common entity, accounting for approximately 5 to 40% of cases of pediatric dysphonia and are generally seen in children with excessive voice use or behaviors like crying and yelling, which may lead to vocal trauma[3]. Other etiologies of pediatric dysphonia include laryngopharyngeal reflux, eosinophilic esophagitis, vocal fold cysts and polyps, vocal fold immobility, and rarely, pediatric laryngeal neoplasms.

Pediatric dysphonia has shown to have a significant influence on self-esteem, self-image and perceptions of children by peers, and may greatly impact patient socialization and quality of life.[4,5] Furthermore, given the natural vocal transitions that occur as a child grows, certain pediatric voice disorders may be minimized or even overlooked; it is crucial for the pediatric otolaryngologist to pursue thorough, expeditious diagnosis of pediatric voice disorders, to minimize the impact on development and help distinguish between potentially worrisome underlying etiologies.

Given the broad spectrum and complexity of pediatric dysphonic conditions, a specialized approach to management of these conditions is key and must take into consideration the various factors contributing to vocal dysfunction in childhood, while also tempering parental expectations.

Pediatric Laryngeal Anatomy
Optimal management of pediatric dysphonia requires a thorough understanding of the dynamics and growth of the pediatric larynx. The pediatric voice owns many distinct features and undergoes a complex transition into the adult form. In childhood, the larynx is housed much higher in the neck, with the cricoid cartilage sitting around the C3-C4 level and descending into the adult position at C6 by about age 15.3 (Figure I).

The dimensions of the larynx also undergo significant transition as the child grows, altering the tone, loudness,

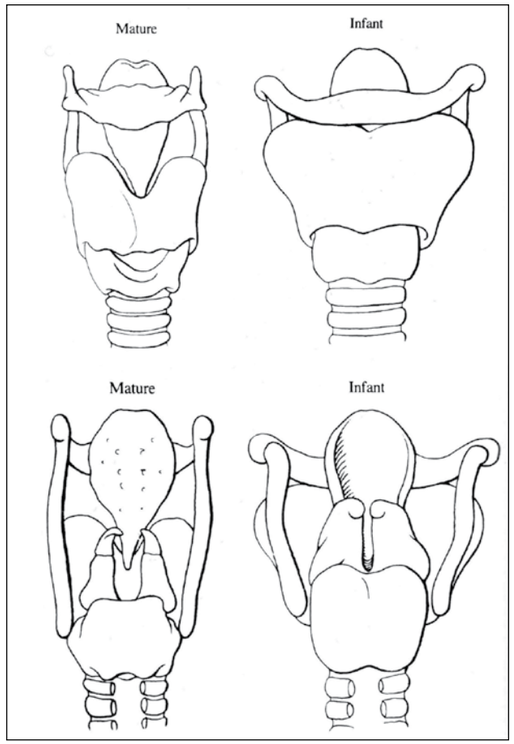

Figure I: *Diagram of the pediatric versus mature, adult larynx. The pediatric larynx exists higher in the neck, and migrates to its more inferior position in the neck by adulthood. The pediatric laryngeal cartilages differ as well, and typically house a more omegoid-shaped epiglottis and more pliable cartilages overall compared to the adult version.*

and pitch of the voice. Specifically, the true vocal folds have been shown to undergo a characteristic evolution during childhood years, with an increase in length through time, as well as changes to the mucosal wave-producing lamina propria layer, both of which contribute significantly to vocal transitions as a child grows.[6] As an infant, the lamina exists as a single, hypocellular layer, and matures into a more organized, cellular, three-layered structure in adulthood.[7]

These structural changes are thought to relate to the functionality required at various stages of life and development, with more rudimentary vocal needs as an infant transitioning to more sophisticated vocalization as an adolescent and adult.[7]

The complexity of laryngeal development and phonation underscores the importance of specialized evaluation and management of pediatric dysphonia. An understanding of the different anatomic features and functional requirements of the larynx at various stages of development is paramount in the proper assessment, as well as medical and surgical management of pediatric voice disorders. In this section, we will focus specifically on the unique assessment and treatment of phototraumatic lesions seen in children.

Assessment of Pediatric Voice Disorders

In pediatrics, the phrase, "children are not little adults" is commonly applied; this concept certainly holds true in the assessment of voice disorders in children. In most adults, the patient can provide a history of their voice complaints, phonate and speak when asked, and will tolerate an office laryngoscopic examination. In children, it is not uncommon to encounter patients who are silent or cry through an entire exam. For this reason, the multi-disciplinary model of assessing and treating these patients is paramount. Speech language pathologists with specialized training in pediatric voice disorders not only provide valuable assessments, which help point to a diagnosis, they can also establish rapport with children and help them to tolerate the examination. The benefits of this engagement are apparent when the patients need voice therapy as well.

Evaluation of voice disorders in children requires a complete head and exam examination. Anatomic factors affecting speech and language should be assessed in addition to a thorough laryngeal exam. Is there nasal congestion or tonsillar hypertrophy affecting resonance? Is there a history of ear infections and chronic otitis media with effusions and hearing loss? Pediatric patients often present with hoarseness in the context of overall poor speech intelligibility and the examination helps to elucidate each of these factors.

The mainstay of the evaluation, however, remains an examination of the larynx with fiberoptic laryngoscopy or videostroboscopy. In younger children, this is performed with a pediatric flexible fiberoptic endoscope, which can be as small as 2.2 or 2.4mm in diameter. Distal chip videostroboscopy can also be performed, as the endoscopes are available in pediatric sizes (3.1 or 3.2mm). Additionally, there are commercially available pediatric rigid scopes for videostroboscopy, which provide images comparable to those provided by standard adult rigid stroboscopes.

In most children, evaluation of the larynx can be completed in clinic and does not require examination under anesthesia. The prospect of a scope exam, though, can be terrifying to children and requires patience as well as child and parental education prior to the exam. While laryngoscopy can be sufficient for some diagnoses, videostroboscopy has the additional benefit of the ability to assess glottal closure, mucosal wave propagation and subtle vocal fold lesions. Challenges to the scope exam in children include shorter attention spans, difficulty completing vocal tasks during the exam, and shorter phonation times.

These factors need to be taken into consideration when selecting the mode of evaluation. It is fairly easy to examine a child of any age with a pediatric flexible laryngoscope but laryngoscopy with voluntary phonatory tasks is more commonly successful in children who are at least 3 or 4 years of age. For the less common scenario in which a child cannot tolerate a laryngoscopy, laryngeal ultrasound may also provide information on vocal fold lesions and mobility.[8]

Vocal assessments should also include perceptual evaluations of voice, patient reported outcome measures, and, ideally, acoustic and aerodynamic measures of voice. These instrumental measures of voice allow practitioners to assess the severity of voice disorders and objectively measure treatment outcomes. Inter and intra-rater reliability is strong for the Consensus Auditory Perceptual Evaluation of Voice (CAPE-V) in children.[9] There are multiple options for quality-of-life assessments in the pediatric setting as well. This includes the pediatric voice related quality of life (PVRQOL) survey, pediatric voice outcome survey (PVOS), or pediatric voice handicap index (pVHI). Clinicians should be mindful that these questionnaires are obtained by parental proxy and there may be differences in voice perception and handicap by a parent versus a child.[10]

Diagnoses and Management

Etiologies of pediatric voice disorders are varied, and management depends on an accurate diagnosis. Causes of dysphonia can range from vocal fold lesions, mobility disorders to functional change. Here we will focus on phonotraumatic lesions.

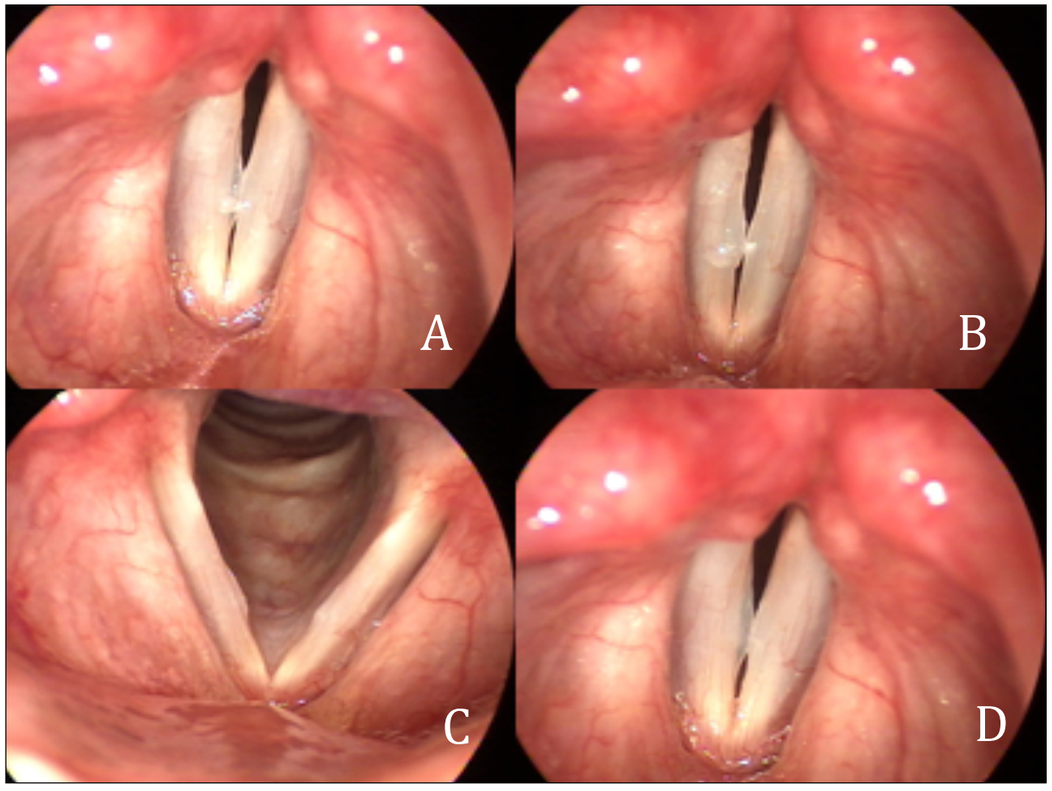

Figure II: *In-office flexible laryngoscopy images of bilateral phonotraumatic lesions during active phonation (A, B, D), and during abduction (C).*

Vocal fold nodules

In the pediatric population, the most common cause of persistent hoarseness remains benign, mid-membranous vocal fold lesions, specifically phonotraumatic nodules. The difficulty in distinguishing lesions such as nodules versus cysts, polyps, and pseudocysts in the adult population is underscored in the pediatric population. The first decision point in managing children with benign vocal fold lesions is often dependent on the question: are these vocal nodules or not? (Figure II).

Nodules are very common in children. By some estimates, rates of dysphonia alone can be as high as 10-11% in school aged children, and of these children 40-60% of them are diagnosed with nodules.[11] In pre-adolescence, nodules are more common in boys. After puberty, this trend reverses and nodules become more common in girls. Etiologies for nodules in children include loud talking, screaming, singing, crying, and making sound effects. Family or parental modeling may also be an exacerbating factor.

There is no set algorithm for the treatment of nodules in children. The management decision tree must account for the age of the child, vocal handicap, and any prior treatments. Some studies have shown resolution of nodules as well as voice complaints after adolescence in approximately 90% of boys. This percentage decreases to 40-50% in girls.[12] In most children, however, voice therapy is the recommended treatment. Surgical excision is less commonly offered, given high rates of improvement with vocal therapy alone in nodules.

Voice therapy in children can encompass a variety of methods. This can range from voice hygiene alone to behavioral modifications including laryngeal massage, progressive relaxation, vocal intensity reduction, pitch elevation, resonant voice and semi-occluded voice tract therapy.

Although there are few publications as to the use of voice therapy in children, the limited data available does suggest there is some benefit from acquiring acoustic and perceptual data provided by ratings such as GRBAS, s/z ratio, and maximum phonation time (MPT). There are also no known negative side effects from therapy.[13,14] Age at which therapy can be initiated is controversial and may depend on the comfort level of the engaged speech language pathologist. Most pediatric voice therapists report that working with children at least 4 years old is most feasible, but do note some success in working with children as young as 2 years old.

Other benign, mid-membranous lesions

Benign, mid-membranous lesions, such as polyps, cysts, pseudocysts and fibrous masses— distinct entities as compared to vocal fold nodules—are less common in children, but their true incidence is unknown (Figure III). Given the challenges of evaluation for pediatric dysphonia, it is likely that many children diagnosed with nodules, in fact, have other benign laryngeal pathologies.[15] For this reason, it is important to follow children diagnosed with nodules, particularly those who do not respond to voice therapy alone or have worsening of their symptoms. Repeat laryngoscopy or videostroboscopy may be valuable in confirming or ruling out a prior nodules diagnosis. As in adults, laryngoscopic findings which may prompt an evaluator to consider diagnoses other than nodules include asymmetric lesions, locations more anterior or posterior to the striking zone of the true vocal folds, and deeper disruption of the mucosal wave.

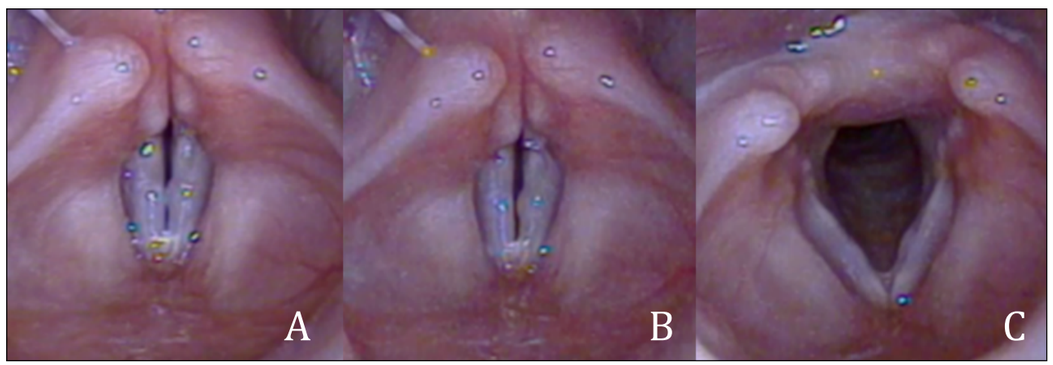

Figure III: *In-office flexible laryngoscopic exam of left true vocal fold cyst during active phonation (A,B) and abduction (C). Note the difficulty in differentiating between lesions in images II and III based on office examination. The vocal fold cyst pictured here was originally diagnosed and treated as vocal fold nodules, which did not improve with conservative therapy, underscoring the importance of obtaining an accurate diagnosis in these cases.*

Treatment for polyps, cysts, pseudocysts, and fibrous masses in kids includes surgical management in addition to voice therapy. The timing and extent of treatment is largely family driven and depends on a child's ability to meet vocal demands. Factors that may prompt more aggressive treatment include frequent aphonia, painful phonation, difficulties communicating with teachers and peers, as well as social stigma and bullying. The decision to pursue surgical management in children with benign vocal fold pathologies must also take into consideration factors such as the ability to adhere to voice rest following procedures, and how this may impact surgical outcomes.

Surgical excision is frequently limited to one side to limit risk of post-operative scarring. This often leaves a contralateral reactive vocal fold lesion that resolves with time and post-operative therapy. Parents need to be counseled of this pre-operatively such that their expectations for voice change immediately following surgery remain realistic.

Special considerations for the pediatric vocal performer

For the young vocal performer, it is imperative to understand the functionality and constraints of the pediatric voice. Child performers may tend to take on stressful and vocally challenging roles with little preparation or training, which makes them particularly prone to phonotraumatic injuries. Instructors of pediatric vocal performers may advise limiting demanding roles until the child has fully matured from a vocal standpoint, including both full anatomical and technical voice development. Selection of a voice coach in the pediatric performer ought to prioritize an understanding of the unique risks to this population, the propensity for vocal overuse, and the need for a team-oriented approach to this challenging and rewarding practice.

Conclusion

Management of pediatric voice disorders requires a specialized understanding of pediatric laryngeal anatomy as well as the specific impact that these disorders may have on children. Phonotraumatic lesions are common, including vocal fold nodules, polyps, cysts, and fibrous lesions. Evaluation of these lesions in children can be challenging, and require adequate experience, proper equipment, good collaboration with speech language pathologists, and tactful management of parental expectations. Management of the pediatric vocal performer warrants special considerations, to avoid vocal overuse injury and allow proper voice development prior to demanding roles.

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Scalp defect - Reconstruction protocol

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Abstract
The scalp defect reconstruction is one of the challenging procedures for the facial plastic surgeon in term of considering the anatomy and physiology of the scalp. The scalp reconstruction options are multifactorial include size, location, related to the hairline of the defect. However, the surgeon and patient preference play an essential role in selecting the technique to reconstruct the defect along with these factors. In this article, we are covering the related anatomy, detailed reconstruction protocols, and complications of the scalp reconstruction as a review article.

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Key words
Scalp defect, Reconstruction, Wound Healing

Clinical Anatomy
The clinical anatomy of scalp is crucial for a better understanding of how to tailor scalp defect repair options. The Scalp has five distinctive layers which are usually describe as SCALP (S: Skin, S: Subcutaneous tissues, A: galea Aponeurosis, L: Loose areolar tissues, and P: pericranium).

The scalp skin adheres as one unit with the subcutaneous layer. The neurovascular bundles run at the subcutaneous tissue layer which, has a significant impact during dissection in terms of preservation of the flap viability[1]. The galea aponeurtica is inelastic, and stiff and is attached to the frontalis muscle, occipitalis muscle and temporoparietal fascia at the anterior, posterior and lateral ends of the scalp respectively. The galea aponeurtica fuses laterally at the temporal line which result in a loose and an inelastic transition zone at this level. So, the flap superior to this line is inelastic and difficult to mobilize[2], while the inferior is loose rendering elasticity to the overlying skin[3]. The fifth layer is the pericranium, that directly adheres to the calvarium and nourishes the skull bone.

The scalp is supplied by both internal and external carotid artery[4]. The frontal scalp is supplied by both supraorbital and supratrochlear arteries, which are branchs of the ophthalmic arteries that originate from internal carotid artery. The temporoparietal part of the scalp is supplied by superficial temporal artery which is terminal branch of external carotid artery.

The occipital and posterior auricular arteries which originate from the external carotid supply the posterior part of the scalp. Below the nuchal line at the posterior part the scalp is supplied by the musculocutaneous perforators from splenius and trapezius muscles[5].

The lymphatic drainages of the scalp drain at parotid, jugulodigastric, posterior auricular, and occipital lymph nodes[6].

The nerve supply of the scalp is provided by three main branches of the trigeminal nerve. Supraorbital and supratrochlear branches of ophthalmic division supply the anterior part of the scalp up to the vertex. Zygomaticotemporal branch of maxillary division supplies the lateral part of the scalp up to the temporal line. Auriculotemporal branch of the mandibular division supplies the lateral part of the scalp anterior to the auricle. Greater occipital and lesser occipital nerves which are branches of cervical spinal nerve and cervical plexus respectively supply the posterior part of the scalp posterior to the auricle.

The temporal branch of the facial nerve runs at the midzygomatic arch to supply the frontalis and corrugator muscles accompanied by the superficial temporal artery at the temporoparietal fascia.

The scalp has two main functions which are protection the calvarium and cosmesis as the scalp is the hair bearing skin[4].

Reconstructive Options;
Reconstruction options of scalp defect range from secondary intention healing to free flap reconstruction. However, the selection of each option depend on many factors; size and site of the defect, distortion of hair line, potential radiation exposure and pericranium integrity[1].

General factors that need to be considered are age, sex, medical fitness, and patient preference. (Table 1)

Table 1: Factors that affect reconstruction options selection

Local	Systemic
Size	General health of patient
Site (above or below temporal line)	Patient preference
Distortion hair line	Age
Radiation Exposure	Sex
Cause of the defect	
Pericranium integrity	

Secondary Intention
The defect can close by itself but with longer wound healing time. Although intact pericranium is crucial for healing, in some cases even without pericranium defects can close spontaneously, but with longer periods, up to three months[7]. Secondary intention provides better outcome at concave sites and with small defects. Prolonged healing period, alopecia, and telangiectasia are considered some of the disadvantages of this option.

Primary Closure
The primary closure can be performed to reconstruct the small scalp defect which is less than 10 cm^2 either superior to the temporal line or inferior to it with different degrees of undermining. The skin lesion excision should be designed as an ellipse (Figure 1) to be closed easily. The local features of the lesion allow the facial plastic surgeon to close the wound primarily. Small, below the temporal line, and the defect proximal to hairline are the ideal wound features to close primarily. However, the irradiated scalp defect has difficulty to close primarily as well as increasing the risk for wound dehiscence.

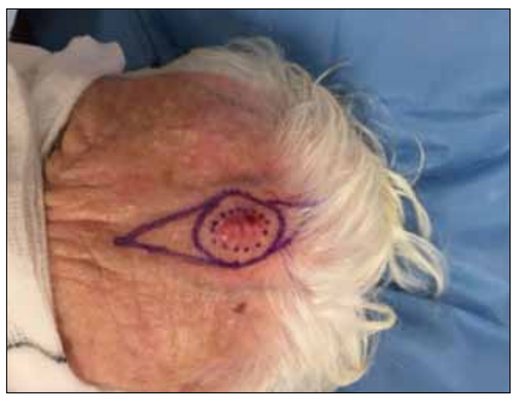

Figure 1: *Ellipse design to forehead and anterior scalp lesions.*

The primary closure is the most preferred method to close the scalp and forehead defects though not always possible[8].

Skin Grafting
Skin grafting is another option to close the moderate size scalp defect[9]. Autogenous graft either split thickness or full thickness skin graft can be used to reconstruct the scalp defect with poor or good matching respectively. The full- thickness autogenous skin graft can be harvested from different sites of the body such as postauricular area, scalp itself or supraclavicular area depending on the defect size, patient preference and accessibility of the graft. While the split-thickness skin graft can be harvested from the upper thigh.

Skin graft can be an adjunct procedure in skin flap for the donor site either as temporary or definitive wound defect closure. Intact pericranium and hematoma prevention measures play an important role to allow uptake the graft.

Although intact pericranium is crucial to the success of a graft, some adjuvant procedures can help save the graft such as drilling the outer table of the skull bone[10] or use artificial dermal regeneration material (Integra) in case of pericranium defect[11,12].

Local Flaps
The scalp has a numerous axial blood supply from all directions as we discussed earlier. Therefore, Varieties of flaps can be designed using these principles from different directions. However, the designed flaps that are either rotational, advancement, or transpositional flaps are not easy to move toward the defect site because of inelasticity nature of galea aponeurotica.

For this reason the direction of designed flap should be aimed to fit with size of intended defect along with consideration to both the direction of incision line and the hairline (Figure 2)[8].

Some of the commonly used rotational flaps such as O-Z flap, advancement rotational flap, pinwheel flap and orticochea flap are based on size, site of the defect and in relationship of the defect to the hairline (Figure 3). Furthermore, the local flap usually can be used in the

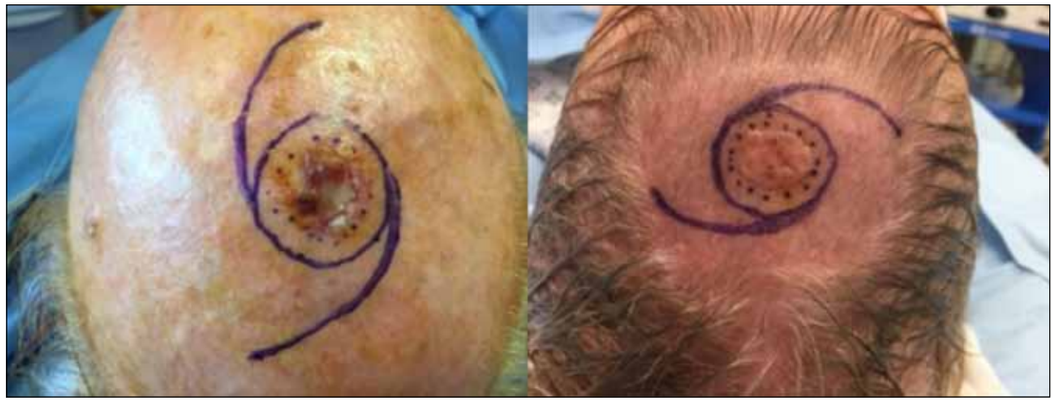

Figure 2: *Direction of O-Z flap can be tailored either antero-posterior or lateral to lateral side depend on skin defect size. Note Curvilinear line of incision.*

moderate to large defect up to 30 cm^2 but not in irradiated skin to avoid flap necrosis. In our practice we commonly use O-Z and advancement rotational flaps.

Free Tissue Transfer

Free tissue transfer flap is a microvascular flap procedure that can close the medium to large defects up to total scalp defect. It is used to reconstruct defects that have been

Figure 3: *Advancement rotational flap is a good option for the lesion close to the hairline.*

radiated before that has jeopardized the blood supply. The tissue transfer flap can be harvested from radial forearm flap which is based on radial artery to anastomose with superficial temporal artery and superficial temporal vein or facial artery and common facial vein. Another option is an anterolateral thigh flap that is based on the perforator arteries.

Although the free flap is a good choice for large defects or irradiated skin scalp it has the morbidity to donor site and mismatching with recipient site.

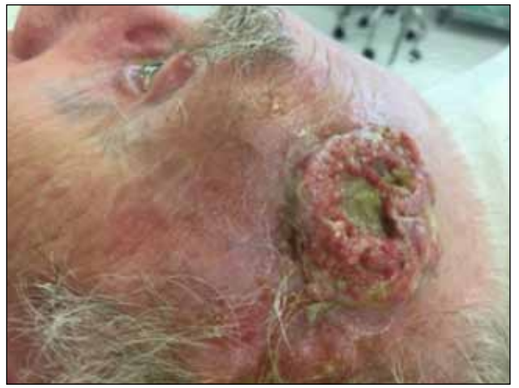

Figure 4: *Left Scalp fungated lesion with central necrosis measured 4*5 c.m.*

Other Procedures

The hair transplant procedure could be an adjunctive procedure for scalp reconstruction repair to achieve the cosmetic goal especially for these procedures that may followed by alopecia. However, the hair transplant procedure can be used to restore the hair-bearing skin or as a camouflage for the scars[13].

Tissue expander can be considered as another option especially for distorted hair line defects but not irradiated skin. It will help to produce up to 2.5 times to the defect size depend on the volume of implanted expander[14].

Conclusion

Anatomical background of the scalp is the keystone to achieve optimal reconstruction result. Scalp reconstruction ranges from secondary intention to microvascular reconstruction flap. Local characters of the lesion and general health condition of the patient play an important role to select the best option to reconstruct the defect.

Case Study

73 years old presented with temporoparietal lesion as shown in (Figure 4). As part of clinical assessment, an incisional biopsy was done that revealed this as desmoplastic squamous cell carcinoma.

1. What is your next step.

a. Explain to the patient nature of the disease

b. Discuss with the patient the treatment plan.

c. Explain to the patient different modalities of management including pros and cons of each.

Figure 5: *Skin graft reconstruct of the scalp defect with full-thickness graft. Fenestrations made to prevent hematoma collection and allow direct contact to underlying tissue*

2. You decided with patient to excise the lesion under local anesthesia. Outline the technical procedure?

a. Supine Position

b. Marking the lesion with 5mm free margin

c. Inject the lidocaine 2% with adrenaline 1:100,000 (Dose 5-7mg/kg)

d. Perpendicular excision lesion at the loose areolar layer with safe margin

e. Label the lesion

f. Hemostasis achievement

g. Reconstruct the defect either with regional graft, local flap or allograft. (Figure 5)

h. Apply dressing

3. What are the potential complications for such management?

a. Infection

b. Bleeding

c. Hematoma

d. Failed graft

e. Residual malignant tissue

f. Skin mismatch

g. Alopecia

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Clinical challenges in management of keloids: A review of literature

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Abstract

Keloids are one of the frustrating complications of the wound healing process that can affect individuals from functional, cosmetic and psychological point of view. For the surgeon this poses a significant challenge. There are several risk factors in keloid formation, some of which are unavoidable. This paper discusses these risk factors, to minimize the likelihood of keloid formation and manage them. Treating of keloids could range from non-invasive to invasive methods with variable success rates.

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Key words

Keloid, Scar, Wound healing

Introduction

Keloid is defined as a proliferative fibrous growth that results from an excessive tissue response to skin trauma[1]. This proliferation spreads beyond the confines of the actual incision. Nature of wound healing varies depending on many factors such as the mechanism of wound injury, racial characteristics[2], and site of the wound. At the cellular level, the type I-III collagen fibers lie in haphazardly connected loose sheets randomly oriented to the epithelial surface[3,4]. Overproduction of fibroblast proteins like transforming growth factor-beta (TGF-b)and platelet-derived growth factor (PDGF) in both abnormal wound healing responses suggests pathologic persistence

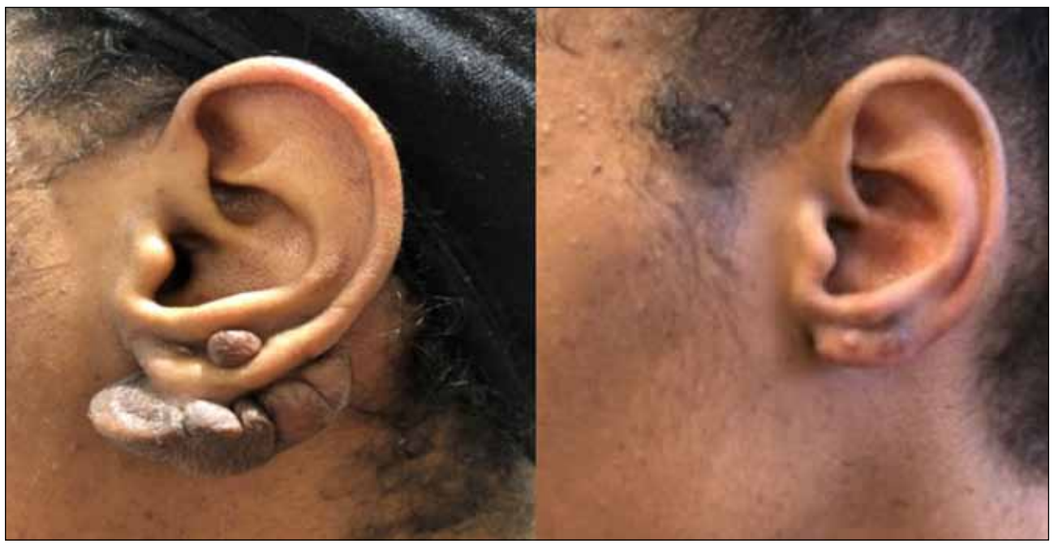

Figure 1: *Showing pre- and Post- Intralesional Steroid management of keloid. Left: Pre-Injections. Right: Nine Months after Injections*

Table 1: summary the detailed management of keloid

	Management	Mode of action	Timing	Dose	Adverse Effect
Primary Measures	Silicone Sheath	• Pressure affect • Induce dermal layer hydration	• Use at first 6 months. • Used as adjunctive therapy	• Positive family history • Wound at aesthetic area • Type V-IV skin	
	Oil Lotion				
	Massage				
Secondary Measures	Surgical Excision	Surgical Removal (Ellipse, Z, or W-plasty)	• After 6 months. • Negative psychological impaction. • Impaired Mobility • Failed Primary measures		Recurrence
	Intralesional Steroid (Triamcinolone Acetate)	Decrease production of TGF-β2		• 10-20mg • 2-4 weeks interval (4-6 months)	Dermal atrophy Telangectasia
Advance Measures	Radiotherapy	Induce Apoptosis of proliferative cells	• Recurrence. • Failed Secondary Measures	• 15-20 Gy 4-5 sessions • 24-48hr postoperatively	Carcinogenic
	Chemotherapy (5-FU)	Inhibit fibroblast proliferation		• 50–150 mg per week for a maximum of 16 injections	Pain Hyperpigmentation
	Cryotherapy	Induce tissue ischemia			
Adjunct Measures	Psychological Counseling				
	Avoid Sun Exposure				

of wound healing or down-regulation of wound-healing cells[5]. There are several risk factors in the formation of keloids that are both preventable and non-preventable which could be related to the patient characteristics, type of trauma or related to skin site. The preventable ones are avoidance of iatrogenic trauma at aesthetically sensitive areas, delicate handling of soft tissues, meticulous surgical technique and minimizing ongoing unintended trauma as well as sun exposure. The challenging part is dealing with the non-preventable risk factors such as genetic predisposition especially for those with V-IV Fitzpatrick skin types[6], positive family history and some non-familial syndromes such as Rubinstein-Taybi and Goeminne syndrome[1]. Tendency to keloid formation is an autosomal dominant condition with incomplete penetration and variable expression. Other contributing factors for keloid formation which play a role include hormonal balance as expressed by regression after menopause, or increase in size during pregnancy[7] as well as a higher tendency in younger age groups. When the keloids form at aesthetically sensitive areas, it becomes a significant burden for both the patient and the surgeon. So, the full preoperative assessment, trying to minimize these risks is the cornerstone of managing the keloid.

Clinical Presentation

A patient with keloid presents with a discolored raised lesion at the wound site which extends beyond its margin in contrast to hypertrophic scar which lies within the margin. The lesion varies in size and color from one patient to the other (Figure 1). One of the important clinical features of keloid is the propensity for recurrence

Figure 2: *Showing pre- and Post- radiotherapy management of keloid Left: Pre-Radiotherapy. Right: Six Months after radiotherapy.*

even after complete excision. The keloid impacts on patients either locally or in general. The local presentation of the keloid ranges from a conspicuous lesion, disfigurement, tingling sensation, severe itching or pain, sensitivity to changes in temperature particularly cold, tenderness and restriction of mobility[8]. The general effects of keloids are psychological impact in terms of decrease self-esteem and in extreme cases depression[9]. Furthermore, the keloid influences the patient's quality of life either directly or indirectly.

Management of the Keloid:

The timing of managing keloid is very crucial and should start as early as possible especially in high-risk patients. The preventive measures of the keloid formation begin when there is a high index of suspicion, for those high-risk patients before keloid formation (Table-1).

The primary measures of keloid management could be instituted as early as possible with up to six months in advance, as adjunctive measures though the value of these measures is questionable. These primary measures include avoidance of sun exposure or application of sun protective cream to the wound, moisturizing the scar, gentle massaging or use the silicone sheets or steroid creams. The mechanism of action of this intervention is still unknown, but it has been suggested that pressure and scar hydration cause fibroblast activity modification and collagen breakdown. All these primary measures play as preventive tools to the progression of keloid or help in regression to some extent of formed and actively proliferating keloid.

Surgical removal is indicated when the primary measures fail to prevent keloid formation, or one of the local or general keloid effects persist for more than six months. The major limitation of surgery as a sole therapy is the very high recurrence rate. Although the bulk of the scar may be removed, the surgery itself causes epidermal injury to keloid-prone patients. However, the role of surgery for keloid management starts as we plan the incision that should be along the relaxed skin tension lines (RSTL). Furthermore, to reduce the risk of scar reformation, it is

imperative to minimize skin tension in the operating room. Careful and meticulous handling of tissue and precise wound edge alignment can help limit adverse healing[10].

The current trend in managing keloid as an office-intervention modality is injection of triamcinolone acetonide. The dose of triamcinolone acetonide is 10-20 mg every 2-4 weeks up to six sessions. It inhibits the fibroblast growth and promotes collagen degeneration which can lead to symptomatic improvement in 72% of patients and complete flattening in 64% of lesions. Adverse effect of intralesional corticosteroids include hypopigmentation, dermal atrophy, and telangiectasia[11].

Advanced measures in treating recurrent keloids are radiotherapy, chemotherapy, or cryosurgery. However, the response rates to radiotherapy vary dramatically across studies. When used, radiotherapy as single or adjuvant modality of management produced relief of symptoms in 55% of patients, but about two third of the scar showed mild or no change in size (Figure 2)[10]. The fact that radiation is a potential carcinogen means it has to be used as an adjusted dose in selected patients.

However, the radiotherapy or injectable steroid could be used as concurrent therapy with surgery to increase the chance of improvement and prevent recurrence especially for those patients who are refractory to single modalities of management.

Cryotherapy has also been used as monotherapy and in conjunction with other forms of treatment for scars. It is thought that cryotherapy induces vascular damage that causes anoxia and ultimately tissue necrosis for the keloid.

Another option to treat keloid is the use of laser technology. Argon laser was the first amongst lasers to be used for keloid therapy. But because of the minimal improvement in scar flattening, it was abandoned for carbon dioxide, Nd:YAG, and flashlamp-pumped pulsed-dye lasers (PDLs).When the carbon dioxide laser was used as a monotherapy, recurrence rates were 90% or higher. The Nd:YAG laser has been used with encouraging results and recurrence rates around 17%. Over the past decade, the PDL, which targets oxyhemoglobin, has been shown to provide durable improvement in hypertrophic scars and keloids.

Conclusion

Keloid formation can be a challenging sequela of a pathological wound healing process. Understanding the cellular pathology and risk factors of the keloid play an important role in its prevention and management. Management of keloids may has to be at multi factorial depending on the severity and intervention time. High success rates are achieved when managing these through multidisciplinary approach.

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Algorithm for the management of lateral crural pathology

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Abstract

Nasal tip deformities are often the most challenging aspect of rhinoplasty. The lateral crus (LC) is an integral component of the nasal tripod and deformities relating to LC size, contour and position can affect the nasal tip architecture.

In this article we aim to describe an algorithm for assessment and management of LC pathology and consideration of available surgical techniques.

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Keywords

Nasal tip-plasty, Lower lateral Cartilages, Lateral Crura, alar rim,

Introduction

The nasal tip is a soft and mobile structure. It's architecture is largely defined by two lower lateral cartilages (LLC). The LLC consist of three anatomic sites: medial, intermediate and lateral crus and abnormality of one or more of these structures can give rise to a myriad of nasal tip deformities (Figure 1). Their interplay with the surrounding structures, including the nasal septum and upper lateral cartilages (ULC), as well as the overlying skin and soft tissue envelope (SSTE) determines the architecture and aesthetics of the nasal tip.

Lateral Crural (LC) deformities are rarer when compared to medial crural deformities particularly in traumatic noses. Deformities of LC not only cause structural issues with the cosmesis, but also impact nasal function causing nasal obstruction in the external nasal valve region. Surgical procedures to correct lateral crural issues are far more complex than correcting medial crural issues. Inadequate or over resection of the lateral crus can result in secondary issues, including asymmetry, alar retraction, alar rim deformities and even external valve collapse. Unsurprisingly, over-resection of the LC and tip asymmetry is the commonest indication for revision tip-plasty in secondary rhinoplasty cases[1] . In recent years the tip-plasty paradigm has shifted towards increased preservation of the LC and controlled modification of its shape and position to create a more functional tip aesthetics.

In this article we aim to review the anatomy and pathophysiology of LC abnormalities and propose a simple algorithm for assessment and surgical planning.

Anatomy

The size, shape and strength of the lateral crus along with the medial crus constitutes a major tip support mechanism. Anatomically the tip complex is not "an ideal" creation of nature. The two Lateral crura are larger and heavier than the medial crus and constitutes the two limbs of the nasal tripod and the conjoined medial crura act as the third limb of the nasal tripod, supporting the weight of the LC. The usual pathophysiology seen in traumatic cases is a weak, fractured or separated medial crus unable to support the weight of the relatively heavier lateral crus. Therefore, the senior author's concept in nasal tip surgery is "*To make the big guy (lateral crus) smaller and lighter, and the small (medial crus) guy bigger and stronger*".

The LC is a broad thin (0.5mm) cartilage arising from the intermediate crus and the dome laterally towards the

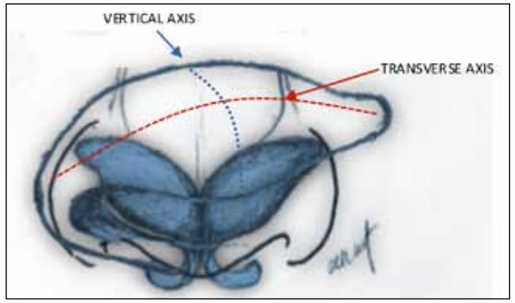

Figure 2: *Anatomy of the LC and its relationship to surrounding structure.*

pyriform aperture (figure 2). It is narrow at the dome and widens in the mid-portion and narrows again laterally[2]. The shape of the LC exists as 3D structure along its transverse and vertical axis[3]. The Transverse axis (medial to lateral) determines the *Length* of LC and defines the convexity and concavity with most LCs seen in population have a varying degree of both. The vertical axis determines the *Width* of the LC. It also determines the relationship between the cephalic and caudal border of the LC and the most aesthetic appearance occurs when the caudal border is higher than the cephalic border[4]. The width of the LC is approximately 11mm at its mid-point with an average length of 22mm[5,2].

The LC has four main borders that determine its interaction with surrounding structures. The caudal border follows the alar margin until the mid-point of the rim before turning cephalad. The cephalic border interacts with the caudal segment of the ULC at the scroll area constituting a major tip support mechanism. It's lateral border interacts with the accessory sesamoid cartilages. Medially the LC is continuous with the dome and the intermediate crus. The cartilage is orientated at 45 degrees from the vertical axis.

Lateral crural algorithm

The main aim of constructing this algorithm is to provide a simple, systematic approach to diagnosis of LC deformities and aid in selection of appropriate surgical techniques. We will examine the Size, Shape, Strength and Site of the LC to identify pathologies and recommend surgical strategies, including sutures, grafting and non-suture non grafting techniques to address these deformities (figure 3).

Pathogenesis of LC deformities: *Primary vs Secondary.*

Assessment of the nasal tip is the key step that determines surgical planning. Overlooking this important step can result in failure to adequately predict the deformities in the alar cartilages prior to surgical intervention. Apart from the clinical experience of the surgeon, there are no special

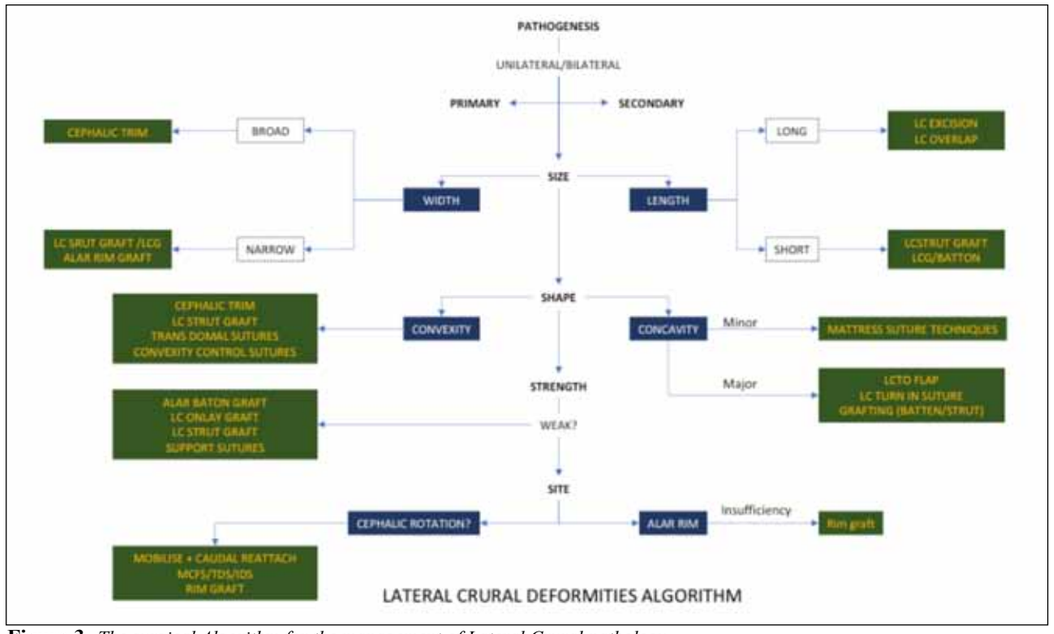

Figure 3: *The surgical Algorithm for the management of Lateral Crural pathology.*

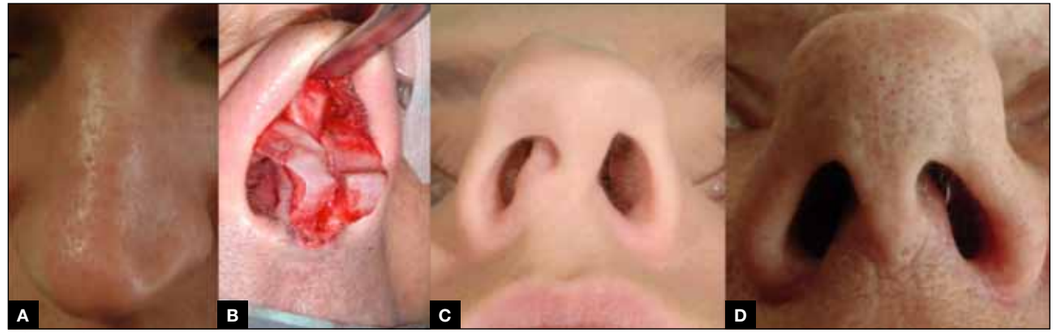

Figure 4: *Pathogenesis of Lateral Crural Pathology.* **A** *and* **B:***. concomitant unilateral Concavity and Convexity of the LC due to primary pathology.* **C:** *gross caudal septal dislocation causing asymmetry and displacement of columella and the LC.* **D:** *early rhinophyma changes to the skin causing additional bulk to the nasal tip.*

tests available in predicting the pathogenesis of the deformity.

In assessing the pathogenesis of the LC deformities, we need to make a distinction between ***Primary deformity*** (i.e arising from the LC) or ***Secondary deformities*** due to SSTE, ULC deformities or the caudal septum abnormalities. It is important to note this interaction as it must be considered in the surgical plan. For example, a very thick SSTE often encountered in ethnic noses can manifest as bulbosity and the subsequent modification to the underlying cartilage may not appear through this thick skin envelope[7]. An additional factor to consider when assessing the LC is whether the problem is unilateral or bilateral as often there will be different pathologies affecting each side and a degree of asymmetry may exist.

Size

There is a significant variation in width and length of the LC in the population and this varies from Caucasian to the ethnic population.

Lateral Crural Width (broad vs. narrow)

The average width of the LC is approximately 11mm. **Broad** LC results in excess bulk and bulbosity of the nasal tip . This is the most frequently encountered configuration

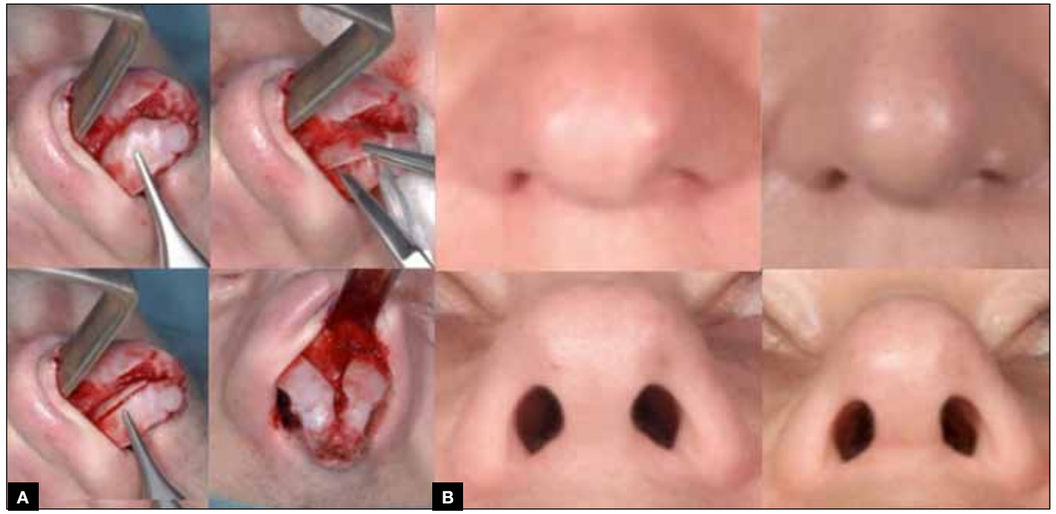

Figure 5: *Broad Lateral Crus. Excess width of the LC increases the bulk of the nasal tip and can be corrected with Cephalic Trimming.* **A:** *demonstrates the technique of performing cephalic trim. It is important to ensure at least 7-8 mm of LC is preserved. Incision is made along the cephalic border and cartilage is excised from the underlying soft tissue. It is crucial to ensure all of the LC is removed as there is often.*

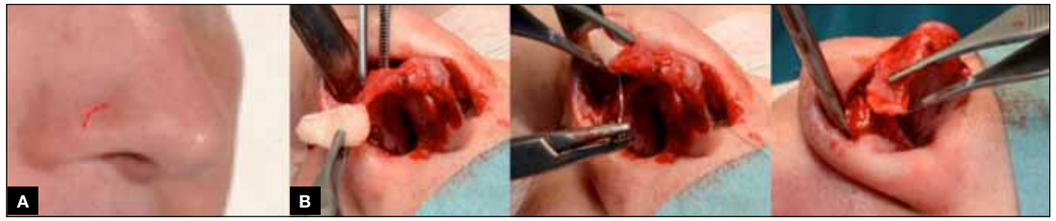

Figure 6: *Narrow Lateral Crus.* **A**. *annotated image to demonstrate the inadequate width of the LC causing collapse and insufficiency.* **B.** *Lateral Crural Strut grafting: cartilage is placed underneath the LC and sutured in place.*

of the LC. In this situation a **cephalic trim** is employed to reduce the width, preserving at least 8mm of LC and the underlying tissue (figure 5). The cephalic border of the LC tends to curl downwards at the scroll area and it is important to ensure that all of this segment is excised. This procedure creates an anatomical dead space that slightly draws in the LC, causing a minor degree of tip upward rotation. If the underlying soft tissue is grossly disturbed it can result in cephalic migration of the LC and subsequent alar retraction[8].

Modifications of this technique have been described to utilise the cephalic portion as either grafts, or hinged/ trans-positional flaps in order to strengthen the LC and reduced the anatomical dead space to prevent unpredictable post-op changes[9].

A ***narrow*** LC is more often encountered in revision cases due to previous over resection or less commonly secondary to congenital causes. It can result in structural abnormalities causing pinching and retraction of the alar rim as well as functional impairment due to external nasal valve collapse. A narrow LC requires reconstruction and we advocate the use of alar grafts including **LC strut grafts** (LCSG) with or without **alar contour graft** (rim graft) (Figure 6).

LC strut grafts are usually harvested form a straight piece of septal cartilage and inserted underneath the LC and securing it using sutures[10]. The graft can be extends to the sesamoid cartilage which can also increase the width by extension beyond the LC caudal border. Because of its fixation to the LC, it can also be used to modify convexity/ concavity of the LC[11] and be used in conjunction with alar rim grafts to camouflage alar rim deficiencies and further extend the width of the LC.

Lateral Crural Length (short vs long)

The length of the LC along the transverse axis plays an important part in tip projection and rotation, where for example a long LC can result in over-projection and under rotation of the tip and vice versa.

In cases where there is a Long LC we advocate LC overlap to reduce the length and de-project the nose. This is performed by interrupting the LC 5-6mm lateral to the dome, and elevating the medial segment from the underlying skin and allowing it to advance over the lateral segment. This results in a moderate degree of tip deprojection. The LC is then stabilised using suture techniques.

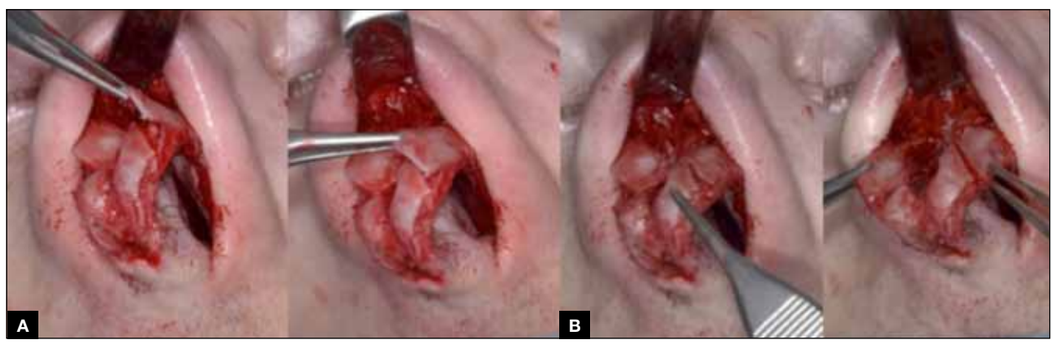

Figure 7: *Long Lateral Crus. Excess length of the LC can result in Tip over-projection and under rotation.* **A:** *Lateral crural Overlap technique: interruption of the LC and mobilisation of the domal segment to over lap the LC.* **B.** *Lateral Crural Excision and re-anastamosis:the desired length is excised and the LC is reattached with sutures.*

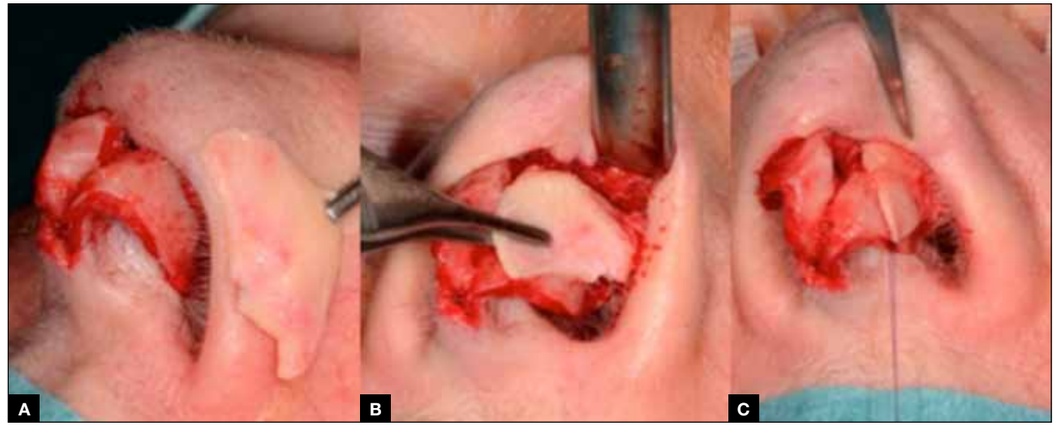

Figure 8: *Alar Batten Grafting.* **A** *and* **B.** *Contra-lateral conchal cartilage graft is used to create the graft with an extended lateral apex to allow overlap onto the pyriform aperture.* **C** *the graft is then secure to the LC with sutures.*

An Alternative approach is to excise a segment of the LC and re anastomose it using sutures, however this can destabilise the LC and result in long term weakness of alar (Figure 7).

A **short LC** can result in under-projection and over rotation of the nose and is commonly seen in revision cases due to over-resection and scar contracture. In such situation additional length can be achieve through LC strut grafts or batten grafting. **Alar Batten grafting** has been utilised in addressing weakened nasal valve to support the LC and the ULC[12] (Figure 8). We harvest this graft from the contralateral conchal cartilage with an extended limb laterally and insert it into a small pocket over the pyriform aperture and secure it sutures to the LC. In addition to allowing extension of the LC and Tip projection, it also strengthen the external nasal valve(ENV) by preventing collapse. In our practice, we tend to favour LC strut grafting over batten grafting. Placing a batten graft on top of the LC adds additional weight to an already weakened LC increasing the bulk and delayed post operative chance of external valve collapse.

Shape`: Convex or Concave

Assessment of the LC shape should take place along its transverse and vertical planes. **Excess convexity** is the most common abnormality seen resulting in bulbosity of the nasal tip. Numerous techniques exist for correcting LC

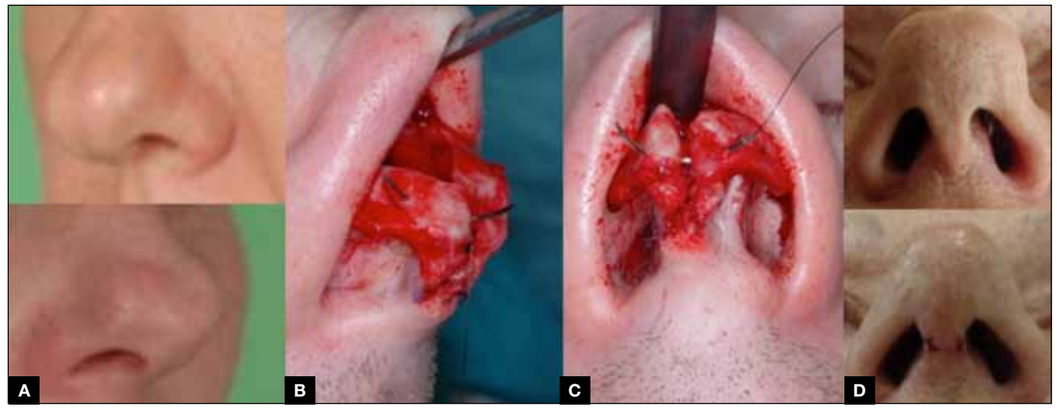

Figure 9: *Excess LC Convexity.* **A.** *demonstrating how Excess Convexity of the LC causes bulbosity of the nasal tip.* **B.** *Transdomal suturing technique: this method can indirectly reduce convexity by applying medial tension to flatten the LC.* **C.** *intermodal suturing is performed to reduce the interdomal distance and can further refine the tip contour.* **D.** *pre and post-op effects of Cephalic trim and TDS and IDS in reducing Convexity and tip bulk.*

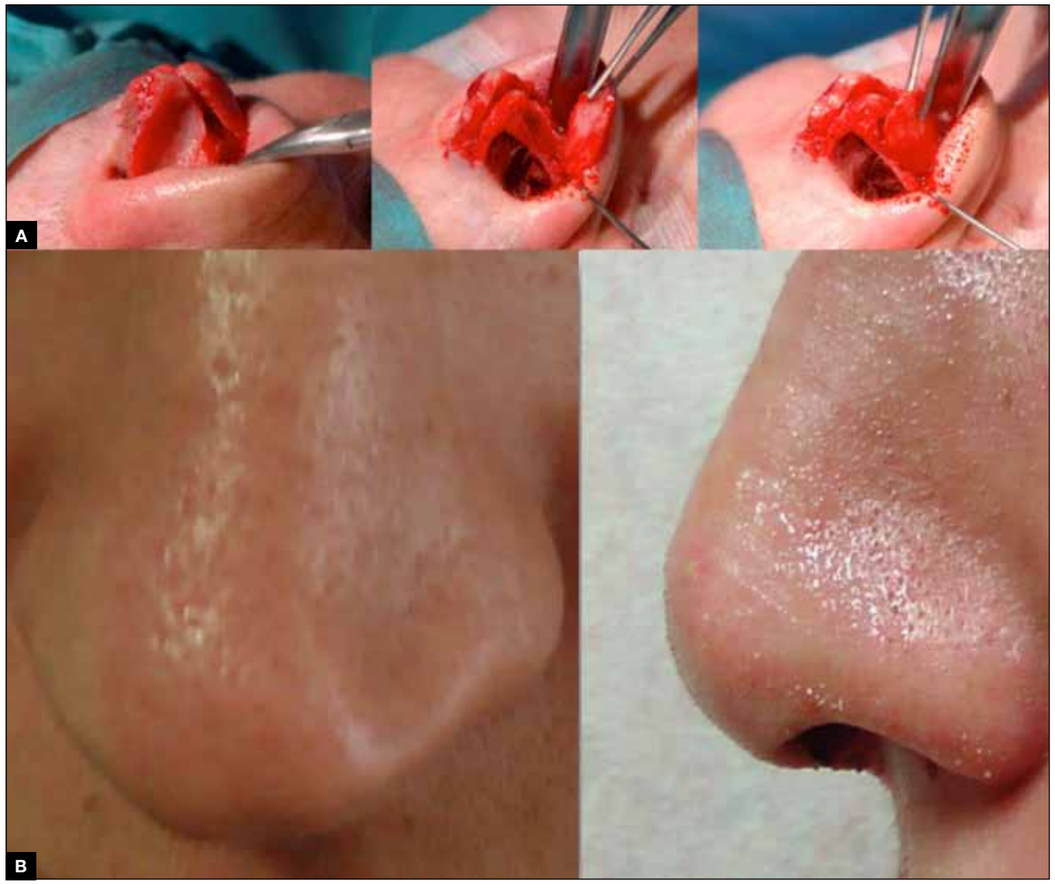

Figure 10: *Lateral Crural reverse plasty (turn in flap).* **A.** *technical aspects of performing LC reverse plasty (turn in flap). The LC is dissected freely and reversed to turn the concavity into a convexity.* **B.** *pre- and post- operative results demonstrating restoration of normal contour of the LC.*

convexity. Most commonly employed are a combination of **cephalic trim** and **suture techniques** that either *directly* or *indirectly* control the LC convexity. We recommend as the first line, **cephalic trim** to debulk followed by **transdomal suturing** (TDS) using either 5.0 PDS or ethilon suture, applying medial tension at the dome to indirectly flatten the LC. If further reduction in convexity is required, then additional Lateral crural convexity control sutures can be employed to directly flatten and strength the LC[13],.

Excess concavity of the LC is usually associated with a fracture or a weak spot at the junction of the lateral crus and the intermediate crus. A concave lateral crus is obvious on examination, seen clearly either in a frontal, lateral or ¾ view. The pattern of light reflection and shadowing is altered with excess light reflection at the alar rim and an acute transition from the tip lobule to the alar region. Internally this can cause obstruction of the internal and external nasal valve and the turbulent airflow created due to reduced cross sectional area at these points causes collapse on inspiration.

Minor concavity of the LC without significant nasal valve insufficiency can be successfully corrected using mattress suturing along the transvers plane of the cartilage 14. Although this technique can be difficult to execute. We find that camouflage grafting is adequate in addressing such minor concavities.

In **Severe** deformities with significant nasal valve dysfunction, a **LC reverse plasty / LC Trun-in Flap** (LCTIF) is a useful technique that allows conversion of a grossly concave LC into a convex shape by reversing the orientation of the cartilage[15] (Figure 10). The LC is mobilised and dissected off the vestibular skin. The cartilage is transected at the medial origin of the concavity, flipped over and sutured back to the remnant intermediate crus and vestibular skin.

An alternative method is the **Lateral crural turn in suture** technique[16] . This can be performed where there is adequate width of the LC preserved. Here, the cephalic half of the LC is mobilised from the soft tissue (Figure 11). A 2mm transverse incision is made medially releasing the cephalic segment and the two concave surfaces are sutured together thereby correcting the concavity and reducing the width of the LC[17] .

Batten grafts and LC strut grafts can also been used in cases where there is over-resected concave LC to correct the concavity and strengthen the nasal valve.

Strength

Anderson's tripod theory emphasises the significant role that each LC plays in nasal tip support[18]. We know that the resilience and strength of the LC is a crucial factor in preventing external nasal valve collapse 19. Assessment of the strength of the LC should take place pre-operatively, and photographic documentation should be obtained of any weakness or collapse particularly on deep inspiration. It must also be noted that certain ethnic noses characteristically have weaker LC cartilages and are associated with thicker skin exerting excess weight[20,21] and this should be factored into the surgical plan. Over resection, fracture, and congenital weakness[22] of the LC can also significantly reduce its strength.

A variety of methods exists for increasing strength and support of the LC most of which have been described above. Grafting techniques such as LCSG and batten grafting remain effective methods of increasing strength and LC stability. LC overlay technique for example has been demonstrated in cadaveric studies to increase the strength and resilience of the LC and the nasal tip[23]. Suture techniques such as mattress suturing, interdomal and transdomal sutures are also useful at increasing strength of the LC[13,14].

Site

We used the term Site to define 2 aspects of the LC position that requires individual evaluation: 1) LC position from the alar margin 2) LC orientation (i.e. angle of rotation from the midline).

The distance between the caudal border of the LC to the alar margin is approximately 6mm[3] at the mid-point of LC. If this distance increases it can result in alar rim deficiency, retraction and notching of the alar rim. In such situations insertion of an **alar rim graft** is a useful method of restoring the contour of the rim and strengthening the external nasal valve. This can be done either as part of the primary procedure where the graft is sutured onto the LC, or as a separate incision laterally to insert a 'matchstick' graft towards the midline.

The distance from the caudal border of the LC to the rim can also increase due to cephalic malposition of the LC (LCCM)24. This is defined as any deviation of the caudal border of the LC away from the alar rim, with a reduction of the angle of orientation between the LC and midline (<30 degrees measured angle from caudal border to the midline[5]).

Cephalic malposition is associated with several characteristics: long alar crease, ball shaped tip, parenthesis deformity and external nasal valve incompetence[25] .

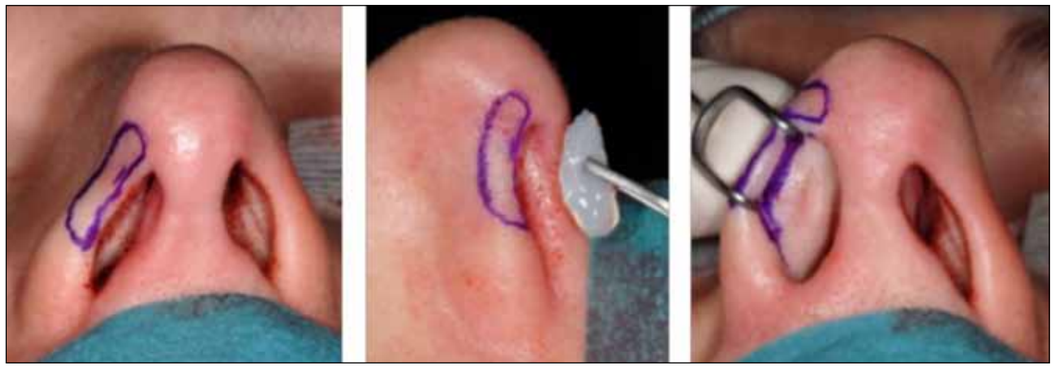

Figure 12: *Alar Rim graft. The deficiency in the alar rim is marked out. A cartilaginous graft is inserted through a separate incision to restore the contour and increase the strength of the alar rim.*

Numerous techniques have been described for correction of LCCM[26,27]. Insertion of a rim graft caudal to the malpositioned LC has been used previously to bring the Caudal border down. However, LC strut grafting has been described as a more successful method of repositioning the LC[10]. In our practice we fully mobilise the LC from the soft tissue bilaterally and create a rotational pivot around the columella by inserting medial crural fixation sutures with or without a strut graft. This manoeuvre can form an arc of rotation that can relocate the LC caudally , which can then be secured with sutures.

Discussion

Control and refinement of the nasal tip is the most difficult aspect of rhinoplasty. Modern rhinoplasty aims to modify the contours of the nasal tip to create a more balanced appearance. A thorough knowledge and understanding of the LLC anatomy and its relationship to the surrounding structures is required for accurate pre-operative planning. We have presented our algorithm for management of the LC pathologies with the aim of simplifying the approach by focusing on key anatomic and physiological characteristics and techniques that can correct and modify these factors to improve nasal tip architecture and function. Most commonly encountered pathology of the LC is a broad convex deformity causing tip bulbosity which is corrected using cephalic trimming and transdomal suturing. Numerous alternative surgical techniques have been described to address other LC abnormalities.

Recent studies have demonstrated and quantified the impact of such techniques on overall nasal tip function[28,29]. It is clear that a conservative approach to LC resection along with preservation and restoration of structural attachments between the LC can reduce the rates of revision tip plasty. This coupled with addition of structural grafts and suturing techniques as well as variable effects of scar tissue formation can add to the overall nasal tip support.

Given the absence of any consensus regarding the ideal surgical strategy for managing nasal tip deformities, this algorithm merely represents our experience with this pathology and the techniques that have provided us with consistent and satisfactory results. As such our recommendations are a general guidance and should be considered in the context of individual patients.

Conclusion

The lateral crus of the LLC is has a 3-dimensional anatomy and constitutes a major tip support mechanism. Its size, shape, site and strength impacts the form and function of the nasal tip. A thorough knowledge of surgical techniques along with fundamental principles of nasal tip architecture is required to control and refine the nasal tip to achieve reproducible, lasting and satisfactory outcomes. Our algorithm aims to address this complex problem in a systematic way.

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Osteoma and Exostosis

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Osteoma. Exostoses. Hearing Loss. Ear Canal, Facial Nerve

Introduction

Ear canal exostoses are smooth, sessile and broad-based bony outgrowths that typically arise on opposing surfaces of the ear canal adjacent to the tympanic membrane. They are frequently discussed in the literature alongside ear canal osteomas which, in contrast, are unilateral and tend to lie more laterally in the canal and in relation to the suture lines. Whilst most are incidental findings in asymptomatic patients, problems present as recurrent otitis externa or a conductive hearing loss arising from cerumen impaction. Exostosis surgery should be reserved for failed conservative treatment: >80% external auditory canal narrowing is considered a threshold, beyond which a greater frequency of infections and sequelae occur[1]. This review presents an overview of both exostoses and osteomas, summarising the role of surgery and its associated risks.

Defining exostosis and osteoma

Exostoses develop as two to three areas of laminated periosteal bone arising from the compact bone that forms the tympanic ring. Histologically, they are composed of concentric lamellae of bone resulting from hyperostosis. Cold water immersion stimulates the successive layering of periosteal bony matrix, initially on the anterior and subsequently the posterior walls[2].

Osteoma are solitary, unilateral, and pedunculated lesions, related to either the tympanomastoid or – less commonly – the tympanosquamous suture lines. It is uncommon that they become so large as to cause obstruction of the ear canal[3]. Histologically, they have a typical appearance of periosteal bone, with an outer cortex and inner cancellous trabeculations with abundant fibrovascular channels[4].

Osteomas and exostoses are distinct clinical entities. Osteomas are benign neoplasms that can occur anytime from childhood, whilst exostoses are considered reactive lesions that occur after puberty. Osteomas are comparatively less common though remain the most common benign tumours of external ear canal. As it is uncommon to be in a position to send a specimen due to the techniques employed in removal, there are scarce reports of the true histopathological findings that distinguish between the entities. The absence of fibrovascular channels has historically been considered to differentiate exostoses from other pathologies[3]. However, Fenton et al.[5] concluded that the presence or absence of fibrovascular channels could not reliably differentiate between the two processes[3].

Natural history

Colloquially referred to as 'surfer's ear', cold water exposure – and the duration of that exposure – are recognised as the key factors in exostosis development[6, 7], as is reflected by a high prevalence in US military divers[8]. Anthropological studies estimate a mean prevalence of aural exostoses in historical populations of 10.8% (range 1.1 to 31.8%)[9]; a higher prevalence is recognised amongst those with greater marine or freshwater exposure[10]. The highest prevalence would be expected in populations between 30 and 45 degrees of latitude and this is borne out across meta-analysis of published anthropological studies[10].

A study of Japanese surfers found more severe exostoses were prevalent in those based in colder seawater areas (<16°C)[11]. Professional surfing and a self-reported willingness to surf in cold water (<60°F) are associated with increased incidence of occlusive exostosis[6].

Both temporal bone and anthropological studies of exostosis have their inherent limitations, since they include cases of osteomata and minor degrees of bony canal swellings. The '*clinical incidence*' is reported to be lower at around 0.64%[12]. The difference in prevalence reported in anthropological and clinical studies, and the number of operations performed in small published series, suggests that in most cases exostoses remain asymptomatic or are never diagnosed[5]. An estimate of the '*surgical incidence*' is between 1.1-5.1 cases/unit/year in Europe to 11 cases/unit/year in larger referral centres from highly populated coastal regions in the US and Australasia[3].

Exostoses typically begin on the anterior wall, with progressive growth and subsequent appearance of posterior canal wall swellings[2]. The main symptoms are hearing loss and recurrent otitis externa[13]. Conservative management with regular atraumatic micro-suction is often sufficient.

Once the ear canal reaches >80% narrowing, the consequences of insufficient access for both topical antimicrobials and effective micro-suction lead to obstruction of normal epithelial migration[14]. Surgery can be considered once conservative measures fail. Secondary surgical indications include access for middle ear procedures, including ossiculoplasty or stapedectomy.

Left untreated, ongoing water exposure will continue to stimulate hyperostosis and expansion of exostoses[7], leading to an increased frequency of sequelae[11]. A '*surfing index*', based on the number of surfing days/week, better correlates with severity than the total duration of surfing in years[11]. The surfing community is increasingly aware of the advice recommending ear canal protection from cold water immersion, though uptake remains low at 25-54%[11,15.] Patients should be counselled about the consequences of a return to surfing and encouraged to adopt practices that minimise exostosis recurrence.

Principles of exostosis and osteoma surgery

Beyond exostoses and osteoma, canalplasty is typically undertaken for stenosing otitis externa and surgical access. Exostoses surgery is unique amongst these indications in that the ear canal skin is typically healthy and requires preservation. When either pathologies are significantly obstructive that they cause symptoms, the clinical picture of either osteoma or exostoses is broadly similar and merit a similar surgical approach, albeit exostoses typically occur medial to the isthmus and osteoma in a more lateral location. The goals of surgery are of improved hearing and achieving an ear canal that can be cleaned or self-cleanses.

Preoperative imaging provides an appreciation of the course of the facial nerve, its relationship to the annulus, and recognition of the degree of aeration of the mastoid portion of the temporal bone (figures 1 & 2).

Several principles of canalplasty ensure the surgery proceeds safely and confidently: (1) surgical access, (2) meatal skin preservation, and, (3) tympanic membrane protection[3,16,17].

The preservation of healthy meatal skin is a priority to avoid post-operative formation of granulation tissue and a resulting fibrous stenosis. A canal skin flap is typically created as medial as is feasible[18]; radial incisions can be extended to enable dissection of the healthy skin from the exostoses. Prolonged post-operative healing, with a requirement for repeated repacking in the medium to long-term, must be stressed when counselling a patient for surgery.

The skin flap is dissected and, once elevated, can be protected using silastic, bone wax[18] or, more commonly, aluminium[19] – sourced from a suture pack – whilst drilling (figure 3). Ensuring adequate lateral exposure permits a safe approach[19,20] and enables the more medial dissection to occur under direct vision. Sanna et al.[19] emphasise that, whilst drilling, '*the movement is always parallel to the*

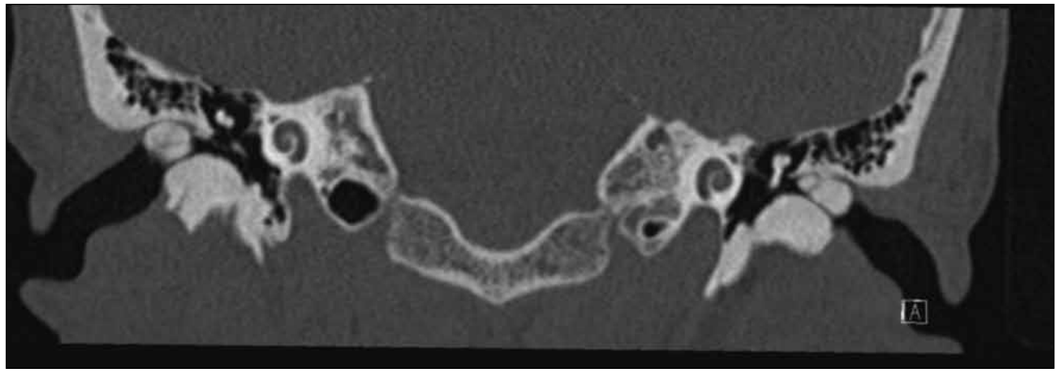

Figure 1: *Coronal computed tomograpy of the temporal bones at the level of the inco-malleolar joint demonstrating bilateral exostoses with adequate self-cleansing of the proximal external ear canal.*

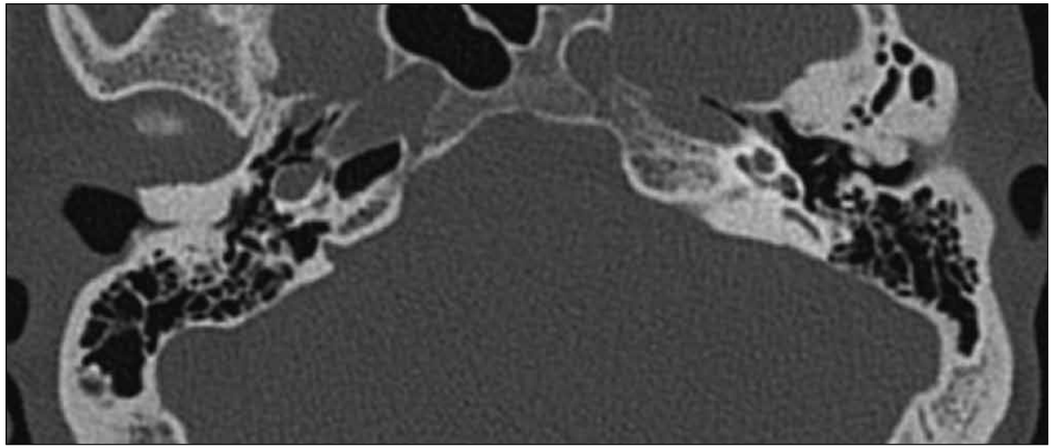

Figure 2: *Axial computed tomograpy of the temporal bones of the same case as figure 1.*

tympanic membrane or in a medial to lateral direction, never lateral to medial'.

Accepting that some skin loss will be inevitable, Tos et al.[3] recommend a '*realistic*' approach to flap management. This is achieved by ensuring the bare area of canal is kept to a minimum, firstly through lateral skin elevation and, secondly, protection of the medial skin by maintaining an eggshell of bone, hollowing out the exostosis. Exposed meatal bone may be covered by temporalis fascia grafting or split thickness skin grafting techniques.

The two key structures at primary risk during exostosis surgery are the facial nerve (posteriorly) and the temporomandibular joint (TMJ) (anteriorly). TMJ disruption leads to both increased post-operative pain and a prolonged recovery[21]. Tympanic membrane perforation is reported in up to 9%[22]. Contact between the drill and neck of the malleus (when drilling medial to the anterosuperior canal wall) has the potential to cause a sensorineural hearing loss; preferentially using a smaller burr size or a curette reduces the risk of this occurring, together with ensuring that the direction of drilling is parallel to the annulus.[19].

Additional complications include restenosis – either bony or fibrous, prolonged healing and granulations requiring frequent post-operative visits for repacking, post-operative infection, and conductive healing loss. Osteomyelitis is a rare but recognised complication[23].

Removal of the anterior exostosis bone is recommended as the initial step, especially when performing a transcanal approach[3]; the posterior canal drilling is not tackled until the tympanic membrane is visible, since the annulus remains the only anatomical relation to the facial nerve in the external auditory canal. The highest risk of injury exists at its posterosuperior aspect[24], arising from a direct or indirect (thermal) injury to the descending portion of the facial nerve. Partial, transient, and delayed facial palsy is reported in up to two per cent, in a large, single-surgeon series[25].

The Facial Nerve

Studies examining the course of the nerve in the region of the annulus universally highlight its variable path. Early plain x-ray studies of the facial nerve found that in 33/50 the vertical segment coursed lateral to the tympanic annulus in its lower half[26]. A cadaveric study based on 37 bones reported this to be the case in 70%24, and in the vast majority, this lateral positioning occurred in the inferior 50% of the vertical segment.

Multiplanar imaging studies similarly emphasise the variability of the lower vertical segment, particularly in paediatric temporal bones[27,28].

Selection of surgical approach

Exostosis surgery is a procedure that may otherwise be regarded as straight forward. The surgery can be undertaken under either general or local anaesthesia, though general anaesthesia is usually better tolerated.

All three surgical approaches – endaural, transcanal or post-auricular – can be utilised, and are effective for removing exostoses. In two of the largest single-institution

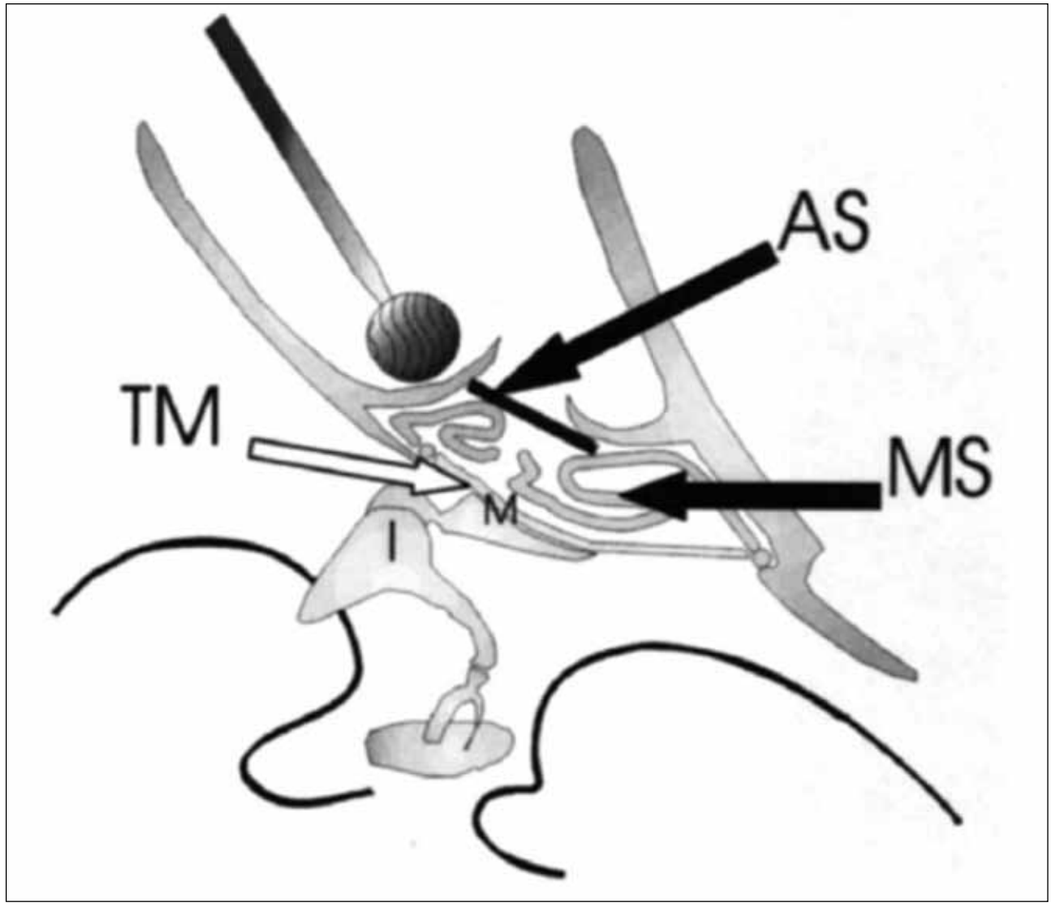

Figure 3: *Tucking the meatal skin flap medial to the constriction. AS = aluminium sheet; MS = meatal skin; M = malleus; I = incus; TM = tympanic membrane.* Reproduced from Sanna 2004[19] (with consent).

published series to date, the approaches reported by Fisher et al.[21] were transcanal (69%), endaural (28%) and post-auricular (3%); in contrast, Grinblat et al.[29] performed a post-auricular approach in the majority (95.7%). Central to selecting an approach is familiarity and experience with a particular approach allowing an understanding of the orientation of the canal during bone removal.

Identification of the spine of Henlé is a vital initial step when faced with significant bony swellings that inevitably distort the canal. This ensures soft tissue elevation proceeds without violation of the lateral canal skin flap. Drilling that is directed towards the superior aspect of the ear canal and into the root of the zygoma can improve this exposure. An endaural approach allows a direct access to the canal superiorly but can limit the size of temporalis fascia graft available for harvest. The post-auricular incision gives better access to the temporalis fascia, without any greater reported complications[19,29,30]. The transcanal approach limits access for tackling the anterior exostosis but ensures more rapid post-operative healing[3]. An endoscopic technique, using a 2mm osteotome-assisted removal of exostosis, reported improve meatal skin preservation and no intra-operative complications[31]. The use of a chisel or micro-osteotome, either solely or in combination with a drill, has been reported to improve safety and tolerance under local anaesthesia[1, 32, 33].

Facial nerve monitoring should be considered essential since, in the absence of landmarks for key structures in the

bony external auditory canal, surgical misadventure can lead to significant complications[17]. A relatively higher rate of facial nerve injury is recognised following canalplasty[34]. It should be highlighted that, whilst widening the posterior canal wall, rolling the patient away from the surgeon will have the effect of positioning the facial nerve between the annulus and surgeon, inadvertently increasing the risk of injury. A technique of addressing only the anterior exostosis via a permeatal approach, with effective results and whilst avoiding the risk of facial nerve injury, has been advocated and may have a selective role[35].

Novel surgical techniques reported in the literature, and alternatives to the traditional drill and osteotome, include the use of an ultrasonic serrated knife for osteoma removal[38], and the use of piezo technology for both exostosis removal[36] and as part of a trial in osteoma surgery evaluating outcomes in ten patients[37].

Measuring outcomes

Outcomes for exostosis surgery primarily report success in terms of re-stenosis or complication rates. Audiometric outcomes include measures of air-bone gap closure and the avoidance of an iatrogenic conductive or sensorineural hearing loss. When operated on primarily for conductive hearing loss, closure of air-bone gap to <10db is reported in 50%[19].

Pre-operative counselling of patients includes the avoidance of ongoing cold-water immersion with advice to adopt techniques to limit likelihood of recurrence. However, given the patient population, patients may be less likely to restrict themselves from future sporting or professional activities that have caused their symptoms.

Conclusions

Exostosis and osteoma are distinct clinical entities, which rarely lead to significant complications and can be managed conservatively in the vast majority of cases. Conductive hearing loss, infections or theoretical risks of ear canal cholesteatoma are sequelae that may warrant surgical intervention.

Distorted anatomy, limited access and proximity of the exostoses to the vertical portion of the facial nerve, TMJ and tympanic membrane, can mean the surgery is challenging and carries greater risk of complications.

Surgical options for managing exostoses include transcanal, endaural, postauricular and endoscopic techniques. Increasing numbers of publications advocate chisel or mini-osteatome removal either in isolation or combined with a surgical drill. Counselling patients prior to exostosis surgery on the risk of re-stenosis requires advice on future avoidance of cold-water immersion and a potential prolonged post-operative healing phase that requires frequent repacking and regular attendance in the outpatient department.

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Assessment and management of paediatric balance disorders

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Abstract
Children with imbalance present infrequently to the ENT surgeon and are often seen by multiple specialties. The main diagnoses in dizzy children include vestibular migraine, central structural disorders and trauma. Balance disorder can be seen in association with sensorineural hearing loss and/or syndromes. However, children can develop any of the balance disorders that we commonly see in adults.

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Key words
Paediatric, vestibular, balance, migraine

Introduction
Around 14.5% of school age children report at least one episode of dizziness in the previous year.[1] Other data suggests that only 0.7% of children attending hospital ENT consultations clinics do so with vertigo, indicating that large numbers do not seek a referral for medical attention.[2]

Children may be seen by paediatricians, otolaryngologists, neurologists or ophthalmologists and often have multiple consultations in multiple specialities, reflecting the wide variety of aetiologies and the anxieties of assessing clinicians in diagnosing dizziness in children.

In many ways, children have similar vestibular physiology to adults and therefore can develop any of the balance disorders seen in adults. In utero, myelination of the vestibular nerve occurs before any of the other cranial nerves.[3] The vestibular system is anatomically intact at birth and undergoes sequential maturation throughout childhood until it is fully developed at around the age of 15.4 Balance maturation is heavily dependant (as in adult vestibular pathologies) on visual and proprioceptive inputs. Evidence of neonantal balance function can be sought by testing the vestibular induced reflexes[4]. Subsequently, in children with vestibular disorders, motor development can be delayed.

In a review of 472 children diagnosed in a specialist balance clinic, the most common vestibular diagnoses were migraine (n=98), children with central structural abnormalities (n=66), children post temporal bone injury (n=54) and children with developmental delay (n=50). Dizziness associated with a peripheral vestibular disorder was most commonly associated with either sensorineural hearing loss (SNHL) or hearing loss associated with otitis media (n=34). Inner ear abnormalities (n=32), vestibular hypofunction (n=21) and vestibular neuronitis (n=20) were well represented with fewer patients being diagnosed with Benign Paroxysmal Positional Vertigo (BPPV) (n=8) and endolymphatic hydrops (n=7). Benign Paroxysmal Vertigo of Childhood (BPVC) was diagnosed in 17 of the 472 patients[4]. In contrast; in our secondary and tertiary referral ENT balance clinic, BPVC and migraine make up a much greater proportion of diagnoses in children.

There are, however, many differences between childhood and adult balance assessment. Children express their balance disorder in different terms to adults - the term dizzy may not be used - and they may not be able to describe any preceding factors, tinnitus, hearing loss or their exact sense of motion. Children may be reluctant to play or socialise for fear of falling.

The child may prove challenging to examine and investigate due to the complex nature of the testing involved. There may also be as yet undetected medical issues present, such as Usher's syndrome or cerebral palsy. Significantly, there may be underlying psychological or social care issues.

Referrals
Secondary and tertiary balance clinics with expertise in paediatric dizziness are appropriate for the assessment of the dizzy child. Commonly, assessment is shared with paediatric neurologists, audiovestibular physicians, paediatricians, ophthalmologists and psychologists as appropriate.

Assessment
History
The presenting complaint can be extremely varied, from clumsiness to rotatory vertigo. Table 1 suggests some questions to ask in the history. The first two questions should enquire into the first ever dizzy episode and whether the dizziness is episodic or persistent.

Examination
Examination in children is different to adults, but most elements can be incorporated. It takes longer. Making it fun, with play including games, will allow children to engage with the assessment. Extra tests can be added in - for example, the child can be asked to hop to identify any muscle weakness (muscular dystrophy), or the child could be spun around in the consultation chair (to look for post-rotational nystagmus – this will be absent in vestibular failure). The child can be asked to walk along an imaginary tightrope looking for ataxia and the gait should always be assessed as he/she walks into the consultation room, noting any ataxia or veering to one side.

A detailed neuro-otological examination should be performed. The ears should be thoroughly examined including tuning fork testing. The cranial nerves and cerebellar system should be examined.

Examination of the eyes
Observation of the eyes should be performed in the resting position and during movement to examine for the presence of normal smooth pursuit and nystagmus. Abnormal smooth pursuit may present as saccadic eye movements. Physiological nystagmus can be seen at extremes of gaze but pathological nystagmus always mandates urgent neurological investigation. Nystagmus in the vertical plane is always pathological. For example, down beating nystagmus can be seen in Chiari malformations.[4]

A Dix-Hallpike manoeuvre can be undertaken to elicit any torsional nystagmus associated with BPPV. Although rare in children, we have seen two eight-year-old children in our clinic with classical BPPV.

Head impulse testing may be performed to examine the vestibulo-ocular reflex. It is abnormal if a corrective

Table 1. History in the paediatric balance patient

Questions to ask	Rationale
Can you describe the first episode? What happens during a typical episode? Time course of symptoms? Any Precipitants/triggers? E.g. positional/situational	Positional dizziness is a red flag symptom for a posterior fossa abnormality such as a Chiari malformation. Situational dizziness may suggest a psychosocial trigger
Any accompanying symptoms? E.g. Headache, visual disturbance, tinnitus, hearing loss, loss of consciousness/awareness, drop attacks, vomiting, phono/photophobia	Headache suggests vestibular migraine Loss of consciousness and drop attacks are red flags for non vestibular causes
Any recent trauma?	May suggest wide vestibular aqueduct, vestibulopathy, a temporal bone fracture or perilymph fistula
Is their hearing normal? Does hearing fluctuate?	Balance disorders are more common in those with SNHL. Children with Otitis media with effusion are very commonly unsteady.
Is their vision normal? Have they seen an optician recently? Any recent changes?	Essential for balance development. Poor vision is seen in Usher's syndrome
Neurodevelopmental history	
How is their gait? Do they veer to one side?	
Has the child been diagnosed with any syndromes?	
Did the child reach their developmental milestones?	Balance dysfunction can delay motor development and vice versa
Past medical history	
Any otological procedures?	Previous grommets/mastoid surgery/cochlear implantation
Any arrhythmias?	Red flag for Jervell Lange Nielson syndrome
If female, has menarche began?	If episodes peri-menstrual, this suggests vestibular migraine
Family History	
Any familial migraines?	Common in mothers of those presenting with vestibular migraine
Any history of episodic ataxia?	Episodic ataxia type II

Table 2. Essential investigations for children presenting with severe to profound SNHL[5]

Tier 1. Investigations – for all cases	Rationale
Paediatric history	Including maternal history to identify potential causes
Family history of deafness	
Clinical examination	
Developmental examination	
Family audiograms in 1st degree relatives	Hearing loss may go undetected in relatives
ECG	To identify the long QT segment associated with Jervell Lange Nielson syndrome
Ophthalmology review	40% of children with hearing impairment have ophthalmic conditions (BAPA guide)
Connexin 26 mutation testing	Can cause sensorineural hearing loss
Cochlea/internal auditory meati imaging	Identifies central causes or anatomical abnormalities
Urine for microscopic haematuria	For haematuria associated with Alport's syndrome
Any history of episodic ataxia?	Episodic ataxia type II

Table 3. Further investigations in the child with severe to profound SNHL[5]

Tier 2 – investigations based upon history and clinical findings	Rationale
Serology for congenital infections (CMV, rubella, toxoplasma and syphilis)	Treatment can prevent further hearing loss
Haematology and biochemistry	
Thyroid function testing	Either as part of Pendred syndrome or other syndromes
Immunology testing	
Metabolic screen	
Renal ultrasound	If Branchio-oto renal is suspected
Clinical photography	
Chromosomal studies	
Referral to a geneticist	Consider in all cases
Vestibular investigation	Consider in all cases

saccade is present when the head stops moving; this is always in the opposite direction to the affected semicircular canal and indicates a peripheral vestibular deficit. Normal head impulse testing can be seen in central causes of vertigo.

Romberg's and Unterberger's test can be performed in most children.

Investigations

All patients should undergo appropriate audiological assessment according to their age, including tympanometry. MRI scanning is undertaken in around half of children attending ENT clinics with balance disorders.[2]

In the child who is hearing well, the history can reasonably diagnose migraine, BPPV and BPVC. In the child with severe to profound SNHL, further investigations should be undertaken and are listed in Table 2 and Table 3 alongside the rationale for tests.[5]

Vestibular function testing in children will depend on the age and cooperation of the child and what resources are locally available. As with adults, they should be used to support the clinical diagnosis being made.

Dizzy child diagnoses

Some paediatric balance disorders are unique to childhood. Children can also develop any of the adult balance disorders, but do so less frequently.

There are certain diagnoses that may be life saving, making a broad understanding of paediatric dizziness essential. The child with bilateral vestibular failure will not be able to right themselves in the sea or swimming pool and is at risk of drowning. The dizzy child may be at risk of falling, especially if playing at height. Identifying a prolonged QT segment (as seen in Jervell Lange Nielson Syndrome) may be life saving, whilst diagnosing enlarged vestibular aqueduct may prevent progression of hearing loss. Notably, presence or absence of hearing deficit along with imbalance can have a significant impact on the establishment of a diagnosis.

Vestibular disorders in hearing children

Vestibular migraine (VM) in children

VM is the commonest vestibular disturbance in children and follows the same diagnostic criteria as in adults, according to a 2012 consensus statement by the members

Table 4. Vestibular Migraine diagnostic criteria[6]

A. At least 5 episodes with vestibular symptoms of moderate or severe intensity lasting 5 minutes to 72 hours
B. Current or previous history of migraine according to the International Classification of Headache disorders
C. One or more migraine features with at least 50% of the vestibular episodes – Headache with at least two of the following characteristics: one sided location, pulsatile, aggravated by activity, moderate to severe pain – Photo or phono-phobia – Visual aura
D. Not better accounted for by another diagnosis

of the Barany society and the International Headache Society. (Table 4).

Patients suffering both migraine and VM are very sensitive to sensory stimuli, especially during attacks, and are also likely to have motion sickness.

In general, the examination should be normal between attacks but episodic hearing impairment and nystagmus can been seen. There is diagnostic overlap with Meniere's disease. Management should focus initially on the avoidance of dietary triggers, avoiding dehydration, ensuring sensible sleep patterns and stress avoidance. Menstruation can also trigger migraines and we modify this in some children.

Medication can be considered when attacks happen three or more times per month. Magnesium aspartate[7] has been advocated,. Medication for non-vestibular migraines are also thought to be effective. No randomised controlled trials exist for the treatment of VM and the help of a paediatrician or neurologist may be needed in prescribing for these children. Generic migraine treatment guidelines are outlined for both adults and children by the European Federation of Neurological Sciences[8]. For children, Paracetamol, Ibuprofen, Domperidone and Triptans can be effective for acute attacks. For prevention, Flunarazine or Propanolol are effective[8]. We also use Pizotifen for our children.

Benign Paroxysmal Vertigo of Childhood (BPVC)

This condition is seen in around a fifth of children presenting with imbalance.[2] Usually affecting those 3-8yrs old, it causes episodic short-lived vertiginous episodes[4]. A significant number go onto develop migraines later in life and BPVC is considered a precursor. The International

Table 5. IHD Diagnostic Criteria for BPVC[9]

A. At least 5 attacks fulfilling criteria B and C
B. Vertigo occurring without warning, maximal at onset and resolving spontaneously after minutes to hours without loss of consciousness
C. At least one of the following five associated signs of symptoms: Nystagmus, ataxia, vomiting, pallor, fearfulness
D. Normal neurological examination, normal audiometric and vestibular function between attacks.
E. Not attributable to another disorder

Headache society classification for the diagnosis is noted in Table 5.

Management of BPVC is supportive, with reassurance that symptoms will usually settle. Children and parents should be forewarned about potential migraines in adult life.

Head trauma in children

Children may experience post-concussive syndromes and the same range of traumatic conditions as adults, although they are seen much less frequently in the balance clinic.

81% of children in a case series of 247 patients seen in a sports medicine clinic following trauma, with a confirmed diagnosis of concussion, showed evidence of a vestibular deficit. Patients with vestibular deficit took longer to recover and return to school than those without[10]. BPPV can occur after head trauma in children.

Tumours/central structural disorders

O'Reilly et al noted that 66 of 472 children (13.9%) had a central structural diagnosis.[4] In our 14 year tertiary level balance experience, we have not seen any children present with a brain tumour. In Riina et al's analysis of 119 patients, none had a brain tumour but one (0.8%) had a Chiari 1 malformation[2]. Patients with a Chairi I malformation commonly present with a sub-occipital throbbing headache worsened by activity, Meniere's type hearing loss and tinnitus, together with neurological signs (spinal cord disturbance and lower cranial nerve palsies)[11] Downbeat nystagmus is a feature on Hallpike testing. Diagnosis is with MRI, both essential and urgent as posterior fossa tumours can also present in this way.

Vestibular disorders in children with hearing impairment

Imbalance and Otitis media with Effusion (OME)

The presence of an effusion in the middle can cause balance disturbance[12,13] and is not an uncommon

presentation. 58% of children with long-term effusions show evidence of vestibular dysfunction, with 96% of these improving after insertion of ventilation tubes.[14] The pathophysiological effect of an effusion is currently theorised to be due to the diffusion of substances from the effusion to the inner ear[14], or caused by pressure changes.[15] It seems therefore reasonable that if the history and examination fit with a presentation of OME, ventilation tubes are trialled.

Imbalance and SNHL

SNHL is of particular importance, since in this cohort between 20 and 70% have vestibular dysfunction.[16] 50% of congenital hearing loss in the developed world is due to genetic abnormalities with 30% of this group being syndromic.[17] The aetiological investigation of patients with SNHL is outlined in Table 2 and 3.

There are some notable syndromes with vestibular dysfunction and SNHL as key features. Early recognition can lead to appropriate onward referral and prediction or prevention of further sequelae. It may also be especially important for genetic screening and family planning.

Usher's syndrome

Usher's syndrome is an autosomally recessive inherited condition causing SNHL, retinitis pigmentosa and often vestibular dysfunction.

Three types of Usher's syndrome are recognised. Type 1 has congenital severe to profound hearing loss, vestibular dysfunction and childhood onset of retinitis pigmentosa. Type 2 has moderate to severe hearing loss with no vestibular dysfunction and late onset retinitis pigmentosa. Type 3 has progressive SNHL with varying dysfunction of the vestibular system and onset of retinitis pigmentosa[17].

Pendred's syndrome

This autosomally recessive disorder is the most common hereditary cause of SNHL and is due to a mutation in the SLC26A[4] gene.[17] Patients classically have a severe to profound hearing loss and a goitre. A third have vestibular dysfunction due to dilated vestibular aqueducts, though enlarged vestibular aqueducts can also arise independently of Pendred's syndrome.

Jervell Lange Nielson Syndrome

This is an autosomally recessive inherited triad of SNHL, long QT segment and syncopal attacks.[18] There is a 50% risk of mortality in untreated patients before the age of 15. Treatment of the cardiac element is with beta-blockers although, even with treatment, cardiac events are still noted to occur. Cochlear implantation is an option for those with profound SNHL.[19]

Post-infectious vestibular dysfunction

Vestibular Neuronitis (VN)

VN often occurs following a viral infection, causing signs and symptoms due to unilateral vestibular failure or hypofunction. There is usually a positive head impulse test, horizontal nystagmus and normal neurological examination. Treatment is supportive and children tend to recover much more quickly than adults.

Congenital cytomegalovirus, syphilis and rubella can give rise to audiovestibular dysfunction. Testing is done as part of the investigations for SNHL. (See Table 2 and 3)

Meniere's Disease

Meniere's disease is diagnosed in less than 2% of paediatric balance patients. There is some diagnostic overlap with vestibular migraine.

Summary

Whilst representing a small proportion of ENT practice, accurate diagnosis and management of paediatric balance disorders is key in childhood development. A multidisciplinary approach is often needed. As such, children may first present to general ENT clinics, particularly those with hearing loss. An awareness of the spectrum of disorders is recommended.

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New flaps in head and neck reconstruction

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Abstract
The use of microvascular free tissue transfer to reconstruct head and neck oncological defects is commonplace. Incremental development and modification of techniques and workhorse flaps is how patient and donor-site morbidity is improved. This article will discuss the applications of 2 flaps that are gaining popularity as well as the concept of fascial only flaps in head and neck reconstruction.

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Key words
MSAP; medial sural artery perforator
SCAIF; supraclavicular artery island flap
Free fascial flap, osseo-fascial flap

Introduction
The use of microvascular free tissue transfer to reconstruct head and neck oncological defects is now commonplace. Oncological and reconstructive surgeons are able to offer significant complex resections with curative intent to patients alongside a tailored reconstruction[1-4]. Aims of reconstruction focus on restoring mucosal integrity, aesthetic form and function in both primary or secondary procedures[4,5].

Background
Free flap reconstruction in the head and neck has a rich history of evolution and innovation. In 1969 (published in 1972) McLean and Buncke described the first free tissue transfer which involved the transfer of a free omental flap to a large scalp defect[6]. In 1984, Song et al described the anatomy of the anterolateral thigh flap (ALT) as vessels originating from the descending branch of the lateral circumflex femoral artery whilst it was Koshima et al who popularised its use in head and neck reconstruction[7-9]. It is the most widely used perforator flap in current head and neck practice[1,10,11]. Another important perforator flap, most commonly used in breast reconstruction, is the Deep inferior epigastric perforator flap (DIEP). The first description of its use as a free perforator flap rather than a pedicled or free musculocutaneous flap (rectus abdominus free flap) was by Koshima and Soeda in a head and neck reconstructive case[12]. In 1988 they performed a free DIEP reconstruction on a single perforator for a defect following a subtotal glossectomy.

As surgery and techniques develop, truly 'new' flaps in head and neck reconstruction are a rarity. Incremental development and modification of current or out-of-favour flaps is more likely. Flaps are often revisited out of either necessity due to the requirements of the defect or due to the status of the patient in terms of flap availability or potential donor site morbidity. This article will discuss the applications of 2 flaps that are gaining popularity as well as the concept of fascial only flaps.

MSAP
The medial sural artery perforator flap (MSAP) is gaining popularity in head and neck reconstruction as an alternative to the workhorse radial forearm free flap (RFFF) when a thin pliable flap is required[13,14]. Cavadas et al first described its clinical application in 2001 for the free flap reconstruction of lower limb defects[15]. The medial sural artery arises from the popliteal artery and travels in an intramuscular course within the medial gastrocnemius muscle. Markings are made in the standing position as

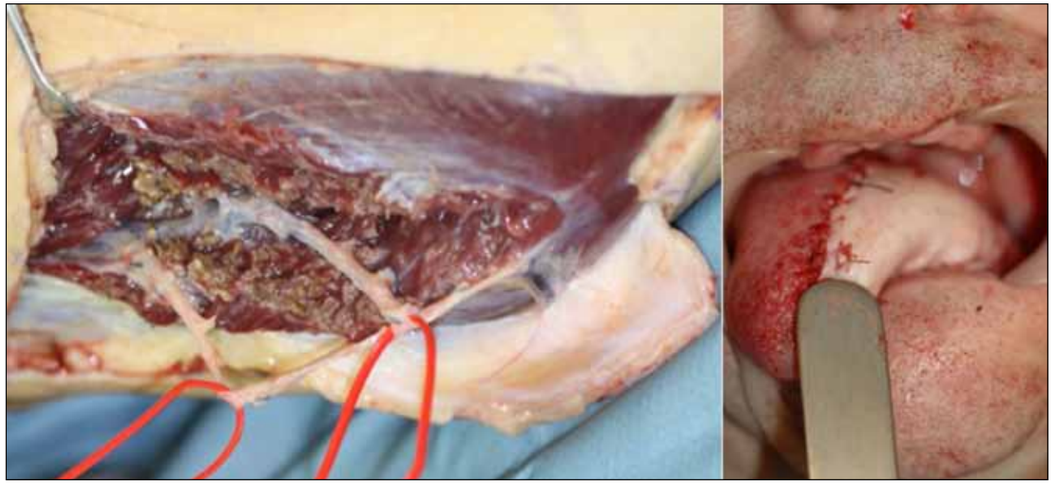

Figure 1: *Medial sural artery identified proximally. Intramuscular dissection with the 2 perforating vessels in vessel sloops. Left partial glossectomy reconstructed with a free MSAP flap.*

described by Kim et al[16]. Mark the popliteal crease and its midpoint. Draw a line connecting the midpoint of the popliteal fossa to the medial malleolus. Perforators are identified using a handheld doppler. Along this line, Kim et al identified one perforator at 8cm from the popliteal crease within a distal semicircle of 2cm radius[16]. Another perforator is usually cited at approximately 12cm from the crease[15].

Technique:
Using a 2-team approach, the patient is supine on the table with one hip abducted and knee flexed in a 'frogs-leg' position. The flap is raised from the opposite of the table and the doppler signals are rechecked. Perforator imaging is not required. A tourniquet may be used but is not essential as the intramuscular dissection is relatively bloodless. The medial border of the flap is dissected first and the posterior aspect is completed once the defect dimensions are confirmed. If the flap is less than 5cm, then primary closure is possible. If a larger flap is required, then a split thickness skin graft and negative wound pressure therapy is indicated. Small intraoral defects such as partial/subtotal glossectomy, floor of mouth and cheek mucosa are suitable for reconstruction with the free MSAP flap (Figure 1). Standard post-operative monitoring should be performed and full weightbearing should commence the next day.

Benefits of the MSAP flap when comparing to the RFFF include the ability to provide a scar that can be well-concealed and closed primarily without the need for a skin graft (Table 1). It also preserves the RFFF if required for future surgeries. Also the immobilization of the wrist combined with complications such as poor aesthetics, superficial radial nerve sensory loss in 32% of cases and

Table 1. Profile of MSAP flap. Adopted from Chalmers et al[14]

Blood Supply	Medial Sural Artery branch off the Popliteal artery
Size of Artery	1.8mm
VC	3.1mm
Pedicle length	11.1cm
Number of perforators	2
Flap dimensions	5x8cm
Flap thickness	7.1mm
Donor site	Closed primarily in 91% of cases (32/25)
BENEFITS	Improved donor site morbidity avoiding sacrifice of major artery to the hand Primary closure when flap dimensions of 4-5cm needed Harvest times similar to RFFF
LIMITATIONS	Transfer of hair-bearing skin in males Vessel size discrepancy Perforator harvest techniques required Careful patient selection as thickness can result in bulky flap and poor functional outcome

delayed healing or tendon exposure in 13-22% are avoided[17].

Limitations are that the vascular anatomy is not as predictable as the RFFF. Commonly, the vessels are small meaning that anastomosis in the neck may require use of vessels other than the facial artery such as the superior thyroid. Venous couplers are used and often cope well with vessel size mismatch. Flap thickness is not as thin as that of the forearm so identifying the right defect and assessing the thickness of the calf prior to surgery is essential.

SCAIF flap

Whilst the MSAP flap is gaining popularity as a free flap in head and neck reconstruction, the application of the supraclavicular artery island flap (SCAIF) is becoming more widespread as a pedicled alternative to a free flap[18-20]. The workhorse pedicled flap in head and neck reconstruction is the muscle only or musculocutaneous pectoralis major flap. This is a thick and non-pliable flap that sacrifices a functional muscle. Donor site contour irregularity as well as a bulky pivot point over the clavicle that may also continue to contract means that alternative flaps should be considered. In many cases the indication is for salvage surgery or the patient is deemed not fit to undergo a free tissue transfer. The pedicled SCAIF flap addresses a number of these problems.

Lamberty described an axial supraclavicular flap in 1983 centered on the fasciocutaneous supply from the supraclavicular artery[21]. In 1997 Pallua et al then described the successful use of the supraclvicular artery island flap in the release of burn contractures to the neck[22]. Since then, it's use and applications have increased within the head and neck region allowing reconstruction of tongue, intraoral, through-and-through cheek defects as well as circumferential pharyngoesophageal defects, management of tracheostomal fistulas and also contour defects following parotid surgery[23-28]. With this versatile flap that can be raised in less than an hour in experienced hands, planning, technique, careful handling of the pedicle and reducing pressure around the pivot point is essential for success[29,30].

Technique:

A handheld doppler probe is used to identify the SCA in the triangle formed between the clavicle, sterncleidomastoid and the external jugular vein (Figure 2). It is consistently found at the posterior aspect of the clavicle 7cm from the sternal notch. The SCA should then be traced along its course towards the shoulder tip. The SCA branches from the transverse cervical artery at the base of the neck and runs parallel to the clavicle 2cm from its posterior border.

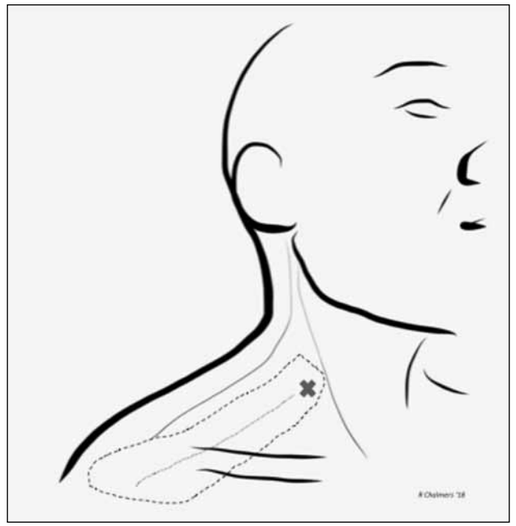

Figure 2: *Supraclaviucular artery is identified in the triangle inferiorly by the clavicle, medially by the posterior border of the sternocleidomastoid and laterally by the external jugular vein with the handheld doppler. The axial course of the artery is marked and the flap dimensions can be drawn.*

Flap lengths of 16-41cm can be raised most reliably within 5cm of the most distal doppler signal[29]. Depending upon the patient, donor site widths of 5-8cm can be closed primarily. If a wider flap is needed then a full-thickness skin graft can be taken from the 'dog-ear' excess upon primary closure around the shoulder and applied to the secondary defect. The flap is raised distal to proximal in a subfascial plane. Identification of the pedicle and skeletonizing the vascular plexus will aid in the reach and rotation of the flap on inset. Preservation of cervical nerves will also provide a sensate flap. A broad subcutaneous tunnel is raised in the neck to pass the flap into the desired defect. Careful attention is made to ensure that the tunnel is released enough so as to minimize compression on the vessels. For an intraoral defect, the flap is rotated 180° and the flap that lies within the tunnel is deepithelialized. For a pharyngeal defect, the midportion of the flap is deepithelialized and the flap is tubed with the skin along the inside of the tube[24].

Benefits of the SCAIF is that it provides a thin pliable fasciocutaneous flap in patients that may not be suitable for a free flap reconstruction (Table 2). It also does not burn any reconstructive bridges allowing free flap reconstruction in the future or a pedicled pectoralis major in salvage conditions. It has also been shown to be reliable in patients who have undergone level IV or V neck dissections as well as previous irradiation therapy[30,31]. A relative contraindication is if a level IV or V radical neck dissection has taken place and there is no documentation if transverse cervical artery has been preserved[27].

Table 2. Profile of SCAI flap

Blood Supply	Supraclavicular artery 3-4cm from the origin of transverse cervical artery
Size of Artery	1-2mm
Pedicle length	20cm
Flap dimensions	5x20cm to allow primary closure
Flap thickness	5-10mm
Donor site	Closed primarily when width 5-8cm
BENEFITS	Thin pliable skin with good colour match Raised in under an hour, reducing operative time and free flap surgery Reliable in previous neck dissection, RT and salvage cases
LIMITATIONS	Careful technique needed to avoid pedicle twist or compression Flap dehiscence and distal tip necrosis is main concern

Limitations of any pedicled flap is the reliability of the distal portion of the flap. Kokot et al presented a case series of 45 patients with a SCAIF reconstruction. Total flap loss was seen in 2 cases, partial necrosis in 8 cases and dehiscence of the flap inset in 11 cases. They identified that flap length >22cm, smoking or history of radiotherapy was associated with flap complications[28]. The results are similar to other authors[20,32].

Fascial only free flaps

With the concept of modifying flaps and revisiting previous innovations, the use of fascial flaps in head and neck reconstruction is also increasing. Consideration of a fascial flap fulfills a number of goals. For intraoral lining it undergoes rapid reepithelialisation and provides a thin covering which is ideally suited for ongoing dental rehabilitation[33]. In addition, the donor site morbidity profile of flaps such as the osseofascial radial forearm flap, the osseo-adipofascial fibula flap or a fascial-only ALT is improved[33-35] (Table 3).

The possibility of using the free ALT as a vascularized fascial flap was first proposed by Koshima et al in the repair of an abdominal defect[36]. Since then, relatively little has been published on fascial only ALT flaps. Bhadkamkar et al used 6 free and one pedicled facial ALT flap to reconstruct the occipital scalp as well as upper and lower limb defects[37]. The ALT was raised using a standard technique. The skin and fat was then excised off the flap and in order to have a very thin reconstruction, the flap was grafted with a split-thickness skin graft. The donor sites were closed directly. This technique of grafting onto the thin vascularized layer is useful if cover of an external defect is required and is used by other authors for similar limb defects[38]. Whilst defatting and thinning of the flap once it is raised in the standard way is a well-used technique, to improve the donor site morbidity further, using a long curvilinear incision, the superficial Scarpa's fascia and deep fascia overlying the rectus femoris can be raised with the perforators so that no skin is excised at all. Cherubino et al describe 11 cases of a fascial ALT in the head and neck including 8 orbital exenteration, 1 forehead reconstruction and 2 palatal reconstructions following maxillectomy[35]. The deep fascia was then grafted with a split-thickness skin graft or a dermal template. No complications were reported. Grafting onto fascia can be unpredictable which is why use of an artificial dermal template can be used. Similarly leaving a layer of vascularized loose areolar tissue over the fascia will improve take.

We have had recent success in a number of young patients where the donor site morbidity profile was important as well as the requirement for a thin vascularised flap with a long pedicle (unpublished). Partial and subtotal tongue defects that also require some added soft tissue volume

Table 3. Profile of fascial flaps

Blood Supply	ALT, RFFF, Fibula – raise using standard techniques without a skin island
Flap dimensions	The fascia can be harvested beyond the dimensions of the standard fasciocutaneous flap design
Flap thickness	5-10mm if raised with superficial fat (Scarpa's)
Donor site	Closed primarily
BENEFITS	Thin pliable flap Will contour well into any defect Avoids transfer of hair bearing Thin mucosalisation permits dental rehbilitation Donor site closed 100% of the time avaoiding need for a skin graft Reports that sensation is improved if skin spared
LIMITATIONS	Inset may be less secure than skin as grip on the tissues is reduced Intraoral healing tends to be sloughy in the early stages Seroma rates at the donor site may be increased

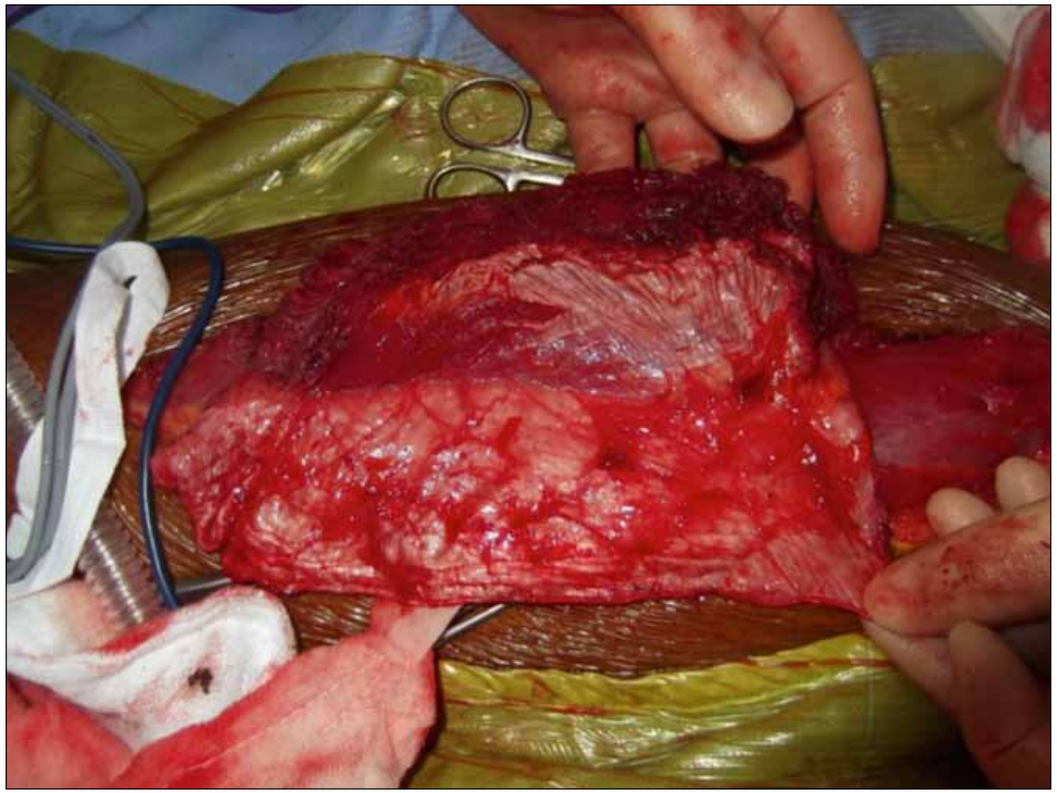

Figure 3: *Right fascial ALT flap harvested with vastus for added bulk. This was used to reconstruct a salvage oropharyngeal tumour + subtotal glossectomy. The donor site is closed primarily with no tension along the wound margin.*

following the selective neck dissections or even salvage cases can benefit from this technique (Figure 3). Optimal donor site outcomes were achieved in all cases.

The utilization of fascial flap component is perhaps best suited to chimeric flaps that a required to reconstruct composite defect requirements. A segmental mandibulectomy and cheek mucosal resection is one such defect. The requirements are of a bony reconstruction which can support dental rehabilitation in the future, intraoral lining to restore mucosal integrity as well as tissue bulk following the cheek resection. Smith et al reviewed 6 cases of patients who underwent reconstruction with a fibula flap and an adipofascial paddle[39]. The adipofascial component was used to either cover the bone and metalwork in a circumferential manner, or approximated to the mucosal margins of the intraoral defect. Mucosalisation will occur on all exposed surfaces. This occurred by 4-7 weeks in their cohort. Muscle only flaps also have this advantage of early mucosalisation but atrophy and unpredictable contraction can be a limiting factor[40].

Summary

In the age of microsurgery and with improved knowledge of vascular angiosomes and perforator techniques, modification and improvements to flaps and their donor sites is ongoing. In this article, we have explored the increased utilization of the MSAP flap, the pedicled SCAIP flap as well as the increasing role that fascial flaps can have in head and neck reconstruction.

Acknowledgements

The authors have no conflicts of interest to declare.

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Management of unilateral vocal fold immobility

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Abstract
Unilateral vocal fold paralysis (UVFP) is a common problem in voice clinics. In recent years, the management of patients with UVFP has changed because of improvements in endoscopic equipment and the advent of new injectable materials. Medialisation procedures have become more readily accessible, and it is now possible to treat patients quickly and simply in clinic, obviating the need for surgical procedures in the operating theatre. A "watch and wait" approach is now no longer considered reasonable, and early intervention is suggested in the vast majority of patients who are symptomatic.

In this article, a variety of techniques is described for achieving medialisation of the paralysed vocal fold.

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Key words
Unilateral vocal fold paralysis
Injection medialisation/Injection laryngoplasty
Thyroplasty/Medialisation laryngoplasty
Laryngeal reinnervation

Presentation
The clinical scenario of the patient with a unilateral vocal fold paralysis (UVFP) will be a familiar one to most otolaryngologists: the patient will typically have a breathy and quiet voice; there may also be a diplophonic (pitch unstable) quality. Many patients will instinctively engage the cricothyroid muscles (obviously innervated by the external branch of the superior laryngeal nerve, and not by the recurrent laryngeal nerve) in an effort to achieve glottic closure: this results in tensioning of the vocal folds, and hence a high-pitched voice. The effort required to produce voice in this situation, combined with the loss of air through the incompetent glottis, leads to rapid vocal fatiguing and often hyperventilation, as the patient is taking multiple breaths in the middle of sentences.

The loss of adequate glottic closure impacts on swallow function, with aspiration of (in particular) liquids, but also saliva. Spontaneous coughing on the patient's own secretions is not uncommon. The loss of glottic competence also means that the strength of the cough is diminished (characteristically described as "bovine"). It is now known that silent aspiration results in excess morbidity and mortality[1].

The degree of breathy dysphonia is very variable and is a function of the position taken by the vocal fold: in general, a vocal fold sitting in a median/paramedian results in better glottic closure, and hence a stronger voice (fig 1a, b). Conversely, a vocal fold sitting in a lateral position (fig 2a, b) will result in a very breathy voice. Most treatments for UVFP are aimed at pushing the paralysed vocal fold into a more medial position.

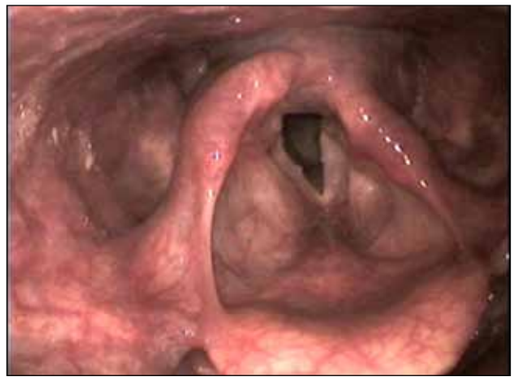

Figure 1: *paralysed left vocal fold sitting in a median position, hence with good glottic closure – on inspiration.*

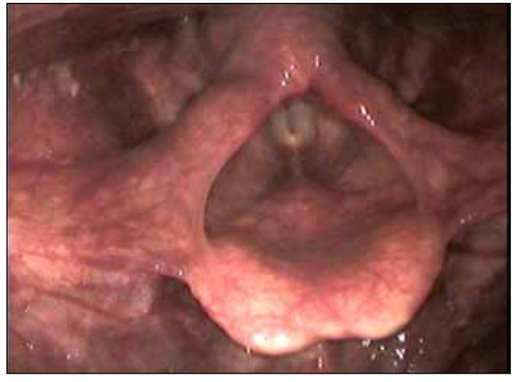

Figure 1B: *paralysed left vocal fold sitting in a median position, hence with good glottic closure – on phonation – good glottic closure is seen, and hence a good voice*

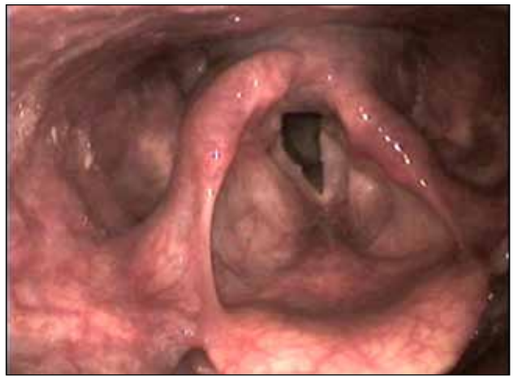

Figure 2A: *paralysed left vocal fold sitting in a very lateral position, hence with a high degree of glottic incompetence – on inspiration.*

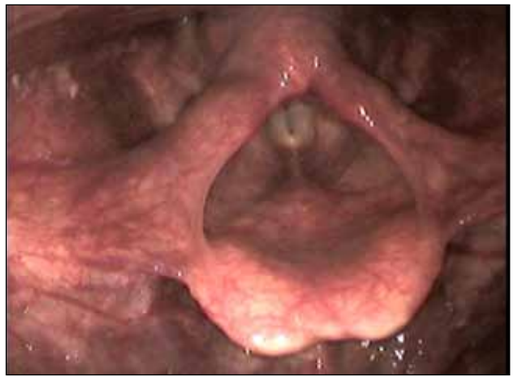

Figure 2B: *paralysed left vocal fold sitting in a very lateral position, hence with a high degree of glottic incompetence – on attempted phonation – a large gap is seen resulting in a very breathy voice.*

Aetiology
The incidence of different aetiologies of UVFP will vary from centre to centre, often determined by other surgical specialties within the hospital: in a centre with a very active vascular surgery department, for example, carotid surgery may be a major causative factor; in a large thyroid centre, thyroidectomy may be the leading cause.

Multiple studies have reviewed the aetiology of UVFP[2,3,4]; the estimated incidences are as follows:

Idiopathic ~ 30%

Iatrogenic ~ 30-50%
- Cervical spine surgery
- Thyroid/parathyroid surgery
- Upper oesophageal surgery
- Carotid endarterectomy
- Thoracic/cardiac surgery

Tumours ~ 10-30%
- Lung, oesophagus, thyroid

Others ~ 10%
- Trauma, inflammatory conditions, neurological disease

Investigation
Having established the presence of a UVFP, the aetiology should now be determined: this may be obvious at the outset (after neck surgery, for example). The neck should be examined, paying particular attention to the course of the vagus and recurrent laryngeal nerve; any palpable masses should undergo targeted investigation (often in the form of cross-sectional imaging and fine-needle aspiration).

In the clinic, subjective assessments should be made of the patient's voice; a patient-reported questionnaire (e.g. Voice Handicap Index) and a clinician-reported rating (e.g. GRBAS, Grade-Roughness-Breathiness-Asthenia-Strain) should be performed. Other useful measurements include the maximum phonation time (MPT), which is shortened in breathy dysphonia and should increase with intervention.

In certain cases, there may be a role for electromyography (EMG): this can help to determine prognosis and may help to direct management. Favourable EMG findings may prompt the clinician to "watch and wait" rather than to intervene early; however, as will be shown below, early intervention is now very straightforward and leads to better long-term outcomes, so prolonged periods of clinical observation (as has been advocated in the past) are generally no longer appropriate.

If a patient is keen to avoid intervention, EMG testing can help to guide them (and the clinician) as to the likelihood of spontaneous recovery of the UVFP – whether the aetiology is idiopathic or iatrogenic.

If the cause of the UVFP is not clear from the history and clinical examination, cross-sectional imaging (CT or MRI) should be undertaken to cover the course of the vagus and recurrent laryngeal nerve on that side. In the case of a right UVFP, this should cover the skull base to the thoracic inlet; left-sided UVFP should undergo imaging from skull base to diaphragm.

If there is any doubt as to whether the vocal fold immobility is due to fixation of the cricoarytenoid (CA) joint rather than a nerve palsy, the patient should undergo an examination under general anaesthetic to palpate the CA joint to assess its mobility.

Management

The management of UVFP has changed significantly in recent years: in the past (and in many of the currently-circulating textbooks), a period of clinical observation ("watchful waiting") was advocated. This approach was based on the fact that interventions to medialise the paralysed vocal fold would generally have involved procedures in the operating theatre, often under general anaesthetic.

However, the advent of newer injection materials, combined with better outpatient endoscopic systems, has made it relatively straightforward to undertake medialisation procedures in the clinic in an awake, unsedated patient.

If the recurrent laryngeal nerve is transected (either deliberately or accidentally) in the course of a surgical procedure, it might (if the surgeon is appropriately trained) be reasonable to perform a primary end-to-end nerve anastomosis. If there is a loss of length of the nerve, an interposition graft using greater auricular nerve can be used.

If the patient presents to clinic, treatment should not be delayed. All patients should be seen by a speech and language therapist to address both the dysphonia, but also the swallowing dysfunction. If there is aspiration (either coughing on swallowing liquids, or aspiration seen on functional endoscopic evaluation of swallowing (FEES) or on a contrast swallow), it is critical that the patient employs techniques to minimise the risk of soiling the lower airways. Typical manoeuvres would include a head turn or a chin tuck; effortful swallow and breath-holds may also be helpful. In cases of severe aspiration, it may be necessary to place the patient nil-by-mouth and instigate enteral (nasogastric or gastrostomy) feeding.

Procedures to medialise the paralysed vocal fold aim to provide bulk to the paraglottic space, pushing the medial vibratory edge of the vocal fold to the midline so that glottic closure can be improved. The medialisation material may either be injected directly into the vocal fold (vocal fold medialisation injection (injection laryngoplasty)) or may be placed into the paraglottic space via a window in the thyroid cartilage (Isshiki Type 1 Thyroplasty (medialisation laryngoplasty)).

Medialisation injection

Vocal fold medialisation injection (injection laryngoplasty) is relatively easy to perform under local anaesthetic in the clinic setting. Equipment requirements are minimal: a distal chip endoscopic system is essential, along with local anaesthetic and the injection material. The injecting surgeon is assisted by a colleague who passes the endoscope; in many centres the assistant is a speech and language therapist or a junior doctor.

It is being increasingly recognised that early medialisation (within a few weeks or even days) following the onset of the UVFP improves long-term outcomes: a series of studies has demonstrated that the longer the delay in performing a medialisation procedure, the more likely it is that the patient will require a thyroplasty in the future[5,6,7,8]. There is therefore little justification for "watchful waiting", and this is radically altering clinical practice amongst laryngologists.

It is also possible to perform injection medialisation under general anaesthetic, but this has some disadvantages: many of the patients in this cohort have multiple comorbidities, so a general anaesthetic may be contraindicated. Patients having a palliative procedure will frequently not wish to have a day-case procedure, or may be too unwell to do so.

There are further advantages to performing injections in the clinic setting:

- The degree of medialisation achieved can be judged in real time, allowing for precision in assessing the amount of material needed. If the injection is performed under general anaesthetic, there is no way of judging how much should be injected.
- The improvement in voice can be assessed by asking the patient to phonate during the procedure. More injection material can then be injected if required.

Different materials can be used, the most common of which are:

- Calcium hydroxylapatite (Radiesse™ Voice, Prolaryn™ Plus, Renú® Voice) is easy to handle and requires no specific preparation. It has a typical duration of action of around 12-18 months.
- Hyaluronic acid (HA) (various proprietary preparations, including Restylane®). This typically lasts around four months. It is therefore ideally suited to those patients in whom a resolution of the UVFP is anticipated, and restores the voice for the intervening recovery period.
- Dissolvable gels (Renú® Gel, Radiesse™ Voice Gel, Prolaryn™ Gel) are synthetic products that have a similarly short duration of action (typically a few months) as hyaluronic acid (HA), and are used in similar situations to HA.

Medialisation injection – techniques under local anaesthetic

Injection medialisations can be performed percutaneously or per-orally.

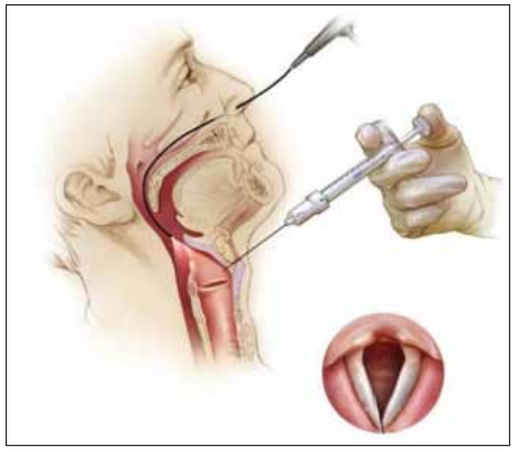

Figure 3: *Trans-thyrohyoid.*

Percutaneous

Under endoscopic guidance, local anaesthetic is injected into the skin and into the airway via the thyrohyoid membrane. The injection needle is introduced into the skin just above the thyroid notch and is then aimed downwards towards the laryngeal introitus (figure 3). The needle often needs to be bent into a curve to achieve the correct trajectory.

Trans-cricothyroid

Under endoscopic guidance, local anaesthetic is injected into the airway via the cricothyroid membrane. The injection needle appears in the subglottis and is aimed upwards towards the undersurface of the paralysed vocal fold.

Figure 4A: *trans-thyrohyoid approach – the needle is seen entering the upper surface of the (paralysed) right vocal fold, taking care to direct the needle lateral to the vocal ligament (hence into the thyroarytenoid muscle).*

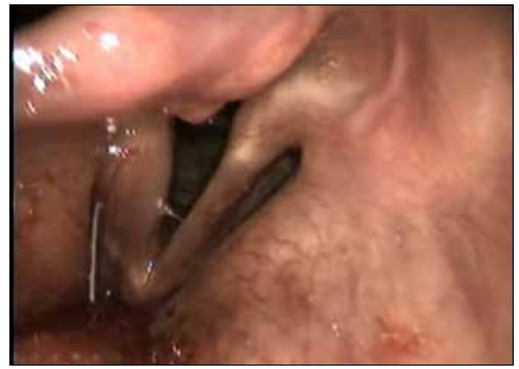

Figure 4B: *trans-thyrohyoid approach – the right vocal fold is filled with injection material.*

Trans-thyroid cartilage

In this approach, the airway is not entered, but the injection needle is passed through the thyroid cartilage into the paraglottic space. This technique can be more difficult if there is calcification of the cartilage.

Per-oral

A long rigid needle is curved to pass over the tongue base towards the larynx. A disadvantage of this technique is the "dead space" in the relatively long needle, so some material is lost.

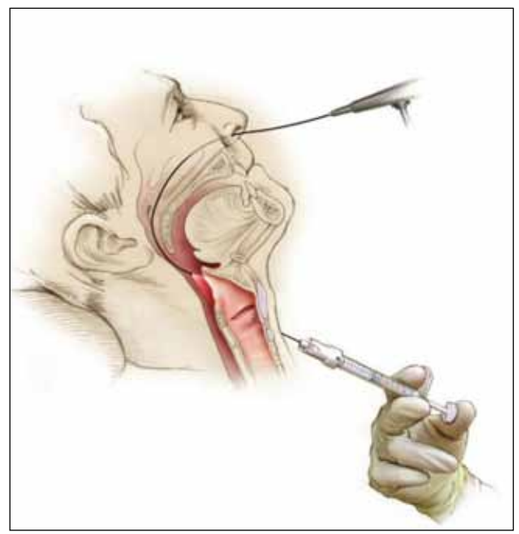

Figure 5: *Trans-cricothyroid .*

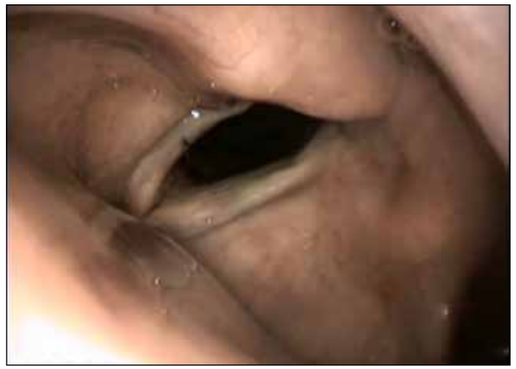

Figure 6A: *the needle is seen entering the airway under the (paralysed) right vocal fold.*

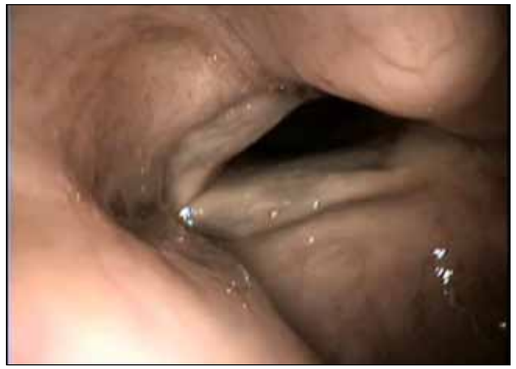

Figure 6B: *the right vocal fold is filled with injection material.*

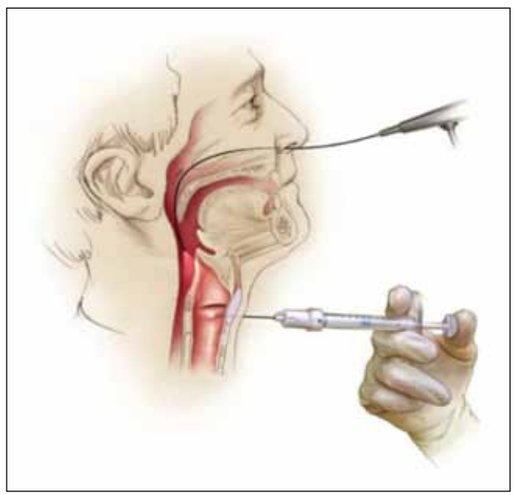

Figure 7: *Trans-thyroid cartilage .*

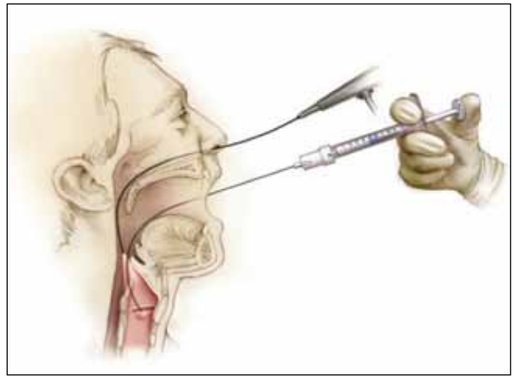

Figure 8: *Per-oral.*

Per-oral

All the local anaesthetic techniques described above take just a few minutes to perform and the patient will typically leave the clinic a few minutes after it is completed. Some clinicians advocate voice rest in order to allow the injection points to epithelialise, and thus to avoid injection material extruding.

Isshiki Type 1 Thyroplasty (Medialisation Laryngoplasty)

If a medialisation injection has been performed but the patient's voice subsequently deteriorates, the injection can be repeated, but consideration should be given to performing a thyroplasty. This procedure is performed in the operating theatre under local anesthetic, often with some sedation. A skin-crease incision is made at the level of the cricothyroid membrane on the side of the UVFP. A sub-platysmal layer is developed, the strap muscles are separated in the midline and the thyroid and cricoid cartilages are exposed.

Markings are made to delineate the position of the vocal folds: the anterior commissure is located exactly halfway between the upper and lower borders of the thyroid cartilage. A window in the thyroid cartilage is fashioned at the level of the paralysed vocal fold; the position of the window is then checked by passing a trans-nasal flexible endoscope. At this point, an implant material (which may be silastic, Gore-Tex ® ribbon, metal or other) is placed through the window into the paraglottic space. The position of the medialised vocal fold is checked endoscopically, and the patient is asked to phonate to check the quality of voice.

The incision is then closed in layers. Voice rest is often advised for two days.

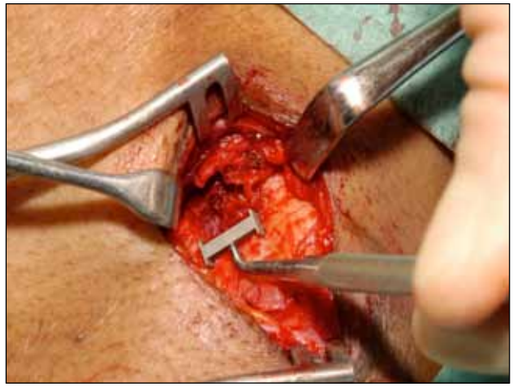

Figure 9: *the window in the thyroid cartilage is measured.*

Thyroplasty has the advantage of being a "definitive" procedure, with an implant that (in theory) will not resorb or move. In rare instances, the implant can extrude into the airway or become infected. In longstanding cases of UVFP, particularly when previous injections have been performed, a thyroplasty is often the most appropriate choice of procedure.

Arytenoid repositioning techniques

In most cases, a medialisation injection or a thyroplasty will achieve adequate glottic closure and result in significant voice improvement. On occasions the arytenoid sits in an unfavourable position and may need to be repositioned[9,10,11]. However, voice outcomes are not demonstrably better when an arytenoid procedure is performed at the same time as thyroplasty, suggesting that thyroplasty alone is usually sufficient[12].

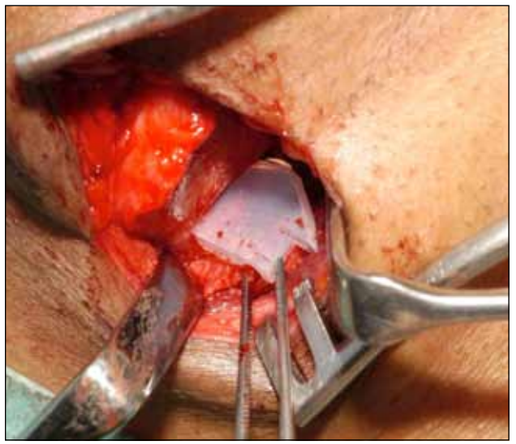

Figure 10: *after fashioning the window, the medialisation material (in this case silastic) is inserted.*

Various different arytenoid procedures have been described:

Arytenoid adduction

Having dissected around the posterior border of the thyroid lamina, the muscular process of the arytenoid is located, and a suture is placed through it and then pulled forwards and secured anteriorly to rotate the arytenoid medially, mimicking the action of the lateral cricoarytenoid (LCA) muscle.

Adduction arytenopexy

The inferior constrictor is detached from the thyroid lamina, the cricothyroid joint disarticulated, the superior thyroid ligament divided and the posterior border of the thyroid lamina retracted anteriorly. The pyriform fossa mucosa is swept away. Inferior to this, the posterior cricoarytenoid muscle (PCA) is identified and followed superiorly to its insertion into the arytenoid. The PCA is then divided at the cricoarytenoid joint and the joint is entered with scissors. After division of the posterior joint capsule fibres, the body of the arytenoid is then sutured posteromedial onto the cricoid facet.

Arytenoid repositioning procedures are perceived as being technically complex and are not in widespread use in the UK.

Laryngeal reinnervation

As has already been discussed, if the recurrent laryngeal nerve is transected at the time of neck surgery, it can be primarily repaired, with or without the use of a nerve interposition graft.

Non-selective reinnervation procedures aim to restore tone and bulk to the paralysed vocal fold, but do not achieve normal laryngeal movement. A branch of the ansa cervicalis is anastomosed to the distal stump of the recurrent laryngeal nerve. Early studies are showing promising results[13,14], but improvements in voice often take several months to be seen, so the reinnervation is often combined with a temporising medialisation injection with (for example) hyaluronic acid.

Studies are planned to compare thyroplasty with laryngeal reinnervation, and a feasibility study is underway[15].

Conclusions

The management of unilateral vocal fold paralysis (UVFP) is changing: it is no longer acceptable to adopt a period of clinical observation ("watch and wait") after a UVFP is identified: early medialisation injection is required to optimise long-term outcomes. Early injection (preferably under local anaesthetic in the clinic) reduces the subsequent

risk of the patient requiring laryngeal framework surgery (thyroplasty). Laryngeal reinnervation is a novel technique and is currently under evaluation: its potential advantages over thyroplasty will become clear with further study.

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A summary of the management of pulmonary nodules in head and neck cancer patients

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Abstract

The management of pulmonary nodules is challenging. Until recently little was known about the incidence and significance of pulmonary nodules in patients with head and neck cancer (HNC). This article summarises some of the British Thoracic Society (BTS) guidelines as well as recent evidence more specifically related to patients with HNC and lung nodules.

Patients presenting with HNC have a higher incidence of pulmonary nodules and a higher risk of malignancy than other groups. In contrast to the British Thoracic Society (BTS) guidelines, which use size to guide the need for serial scans, follow up imaging in all HNC patients with nodules irrespective of size is indicated.

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J ENT Masterclass 2018; 11 (1): 79 - 83.

Key words

Pulmonary nodule, Head and neck cancer, Computerised tomography (CT), Risk factors

Introduction

The investigation and management of pulmonary nodules in the head and neck cancer (HNC) population has been poorly understood for years. Many nodules are incidentally detected in patients on staging computerised tomography (CT). The prevalence is reported to be 11%-33% in high-risk patients[1]. Being able to estimate the risk that pulmonary nodules are either metastatic from the primary disease or represent a new primary malignancy is critical to planning the management of head and neck cancer patients.

In 2015 the British Thoracic Society (BTS) produced a guideline for the management of lung nodules, this was the first guideline to include guidance for patients who already had a known malignancy[2]. However, the evidence used to generate the BTS guidance included only 182 head and neck cancer patients[3-10].

Many patients who pass through the HNC multi-disciplinary team (MDT) are smokers and as such at increased risk of having bronchogenic malignancy, metastatic disease and also benign lung nodules. Previously, UK guidance for head and neck cancer recommended that local policies are developed to guide in the investigation of pulmonary nodules in the HNC population[11].

Summary of the BTS guidance

A pulmonary nodule is a well or poorly circumscribed, approximately rounded structure that appears on imaging as a focal opacity and is both ≤3 cm in diameter and surrounded by aerated lung[2]. The management of lung nodules has evolved due to the increase in evidence on the subject and access to imaging including high resolution CT and PET-CT has improved.

The management approach to lung nodules in the 2015 BTS guidance is based on the size of the nodule and the presence of risk factors. When assessing the risk of malignancy within nodules, 30 studies were included in the BTS guidance[2]. They identified both clinical and

Table 1. Table outlining the patient and radiological risk factors that increase the risk of a malignant pulmonary nodule.

Patient Risk Factors	Radiological Risk Factors
Age	Nodule diameter
Current or former smoker	Spiculation
Pack years of smoking	Upper lobe location
Previous history of extra-pulmonary	Pleural indentation
malignancy	Volume doubling time.

radiological characteristic risk factors that increased the probability of malignancy. Nine risk factors were identified using multivariate analysis (Table 1).

On reviewing the literature a number of studies looking at lung nodules in the HNC population have now been published. Five studies in the BTS guidance derived composite prediction models based on the combination of clinical and radiological multivariate logistic regression analysis[12-16]. Those deemed most appropriate and now used on the BTS website were the Brock and Herder models. Herder et al[16] validated a Mayo clinical model and used flurodeoxyglucose-positron emission tomograpgy (FDG-PET), including extrathoracic malignancy in as a risk in their model.

The Brock and Hereder models are available on the BTS website and should be used to help guide further management and investigation as summarised in Green et al 2017[17]. Individual departments should review their policy for investigation of such nodules. Figure 1 shows the current NHS Lothian algorithm. This is based on the BTS guidance.

Although the BTS guidance is an excellent resource, the lack of specific HNC evidence available limits it applicability to this patient group[2,4,5,6].

In the largest published screening trial, over 53,000 patients were enrolled with a 24% positive finding of non-calcified lung nodules[18]. Less than 4% were subsequently found to be malignant.

The risk of malignancy is the most important question to answer. The BTS used evidence from the Nelson study by Howreweg et al 2014[19] to determine the cut off for discharging a nodule that is less than 5mm or 80mm^3. This was a screening study of over 7000 patients which considered the risk of developing lung cancer over a 2-year period based on the nodule size. They concluded nodules <5mm or 100mm^3 were at no significantly increased risk with 0.6% developing lung cancer in patients with a nodule compared to 0.4% without.

Zammit-Maepel et al[20] found in recurrent and newly diagnosed HNC 7% of nodules initially thought to be benign, were in fact proven malignant on follow up. Those with recurrent HNC cancers were at higher risk of having malignant nodules. This supported previous evidence that those with recurrent HNC are more likely to have malignant involvement of the lungs[21].

In 2013 Alford et al[22] found that patients with higher grade primary HNC, with initially indeterminate lung nodules were more likely to have lung metastases than those with a lower grade malignancy.

Fukuhara et al 2014[23] investigated lung nodules in 332 patients with HNC. Their multivariate analysis identified factors correlating with the risk of lung metastasis. Lung nodules at the initial CT scan in patients with advanced disease were at increased risk with an OR of 2.82.

Beech et al[24] identified lung nodules in only 13% of their study group of 239 patients who had HNC, none proved to be malignant on follow up. They did not include patients with sub 5mm nodules.

A study by Green et al 2017 included 400 consecutive head and neck cancer patients. They found that 58% of patients had non-calcified lung nodules with a 6% malignant rate at follow up. Other studies have reported higher rates from 10.8-19.0%[26-31].

The study by Green et al[25] found that age was the only risk factor associated with the presence of lung nodules[25]. The only risk factor found to be independently associated with malignancy was the stage of the HNC. Advanced disease (stage III+IV) was associated with increased risk in comparison with early stage (stage I+II) disease, with an OR of 10.64. Malignancy was confirmed on the first scan following initial staging in 10 out of the 11 cases.

The BTS guidance identified size as a predictive factor and concluded that there was an OR of 1.1 for every 1mm increment[2]. In contrast to the BTS Guideline, the Green et al paper[25], found neither the actual size nor the grouped

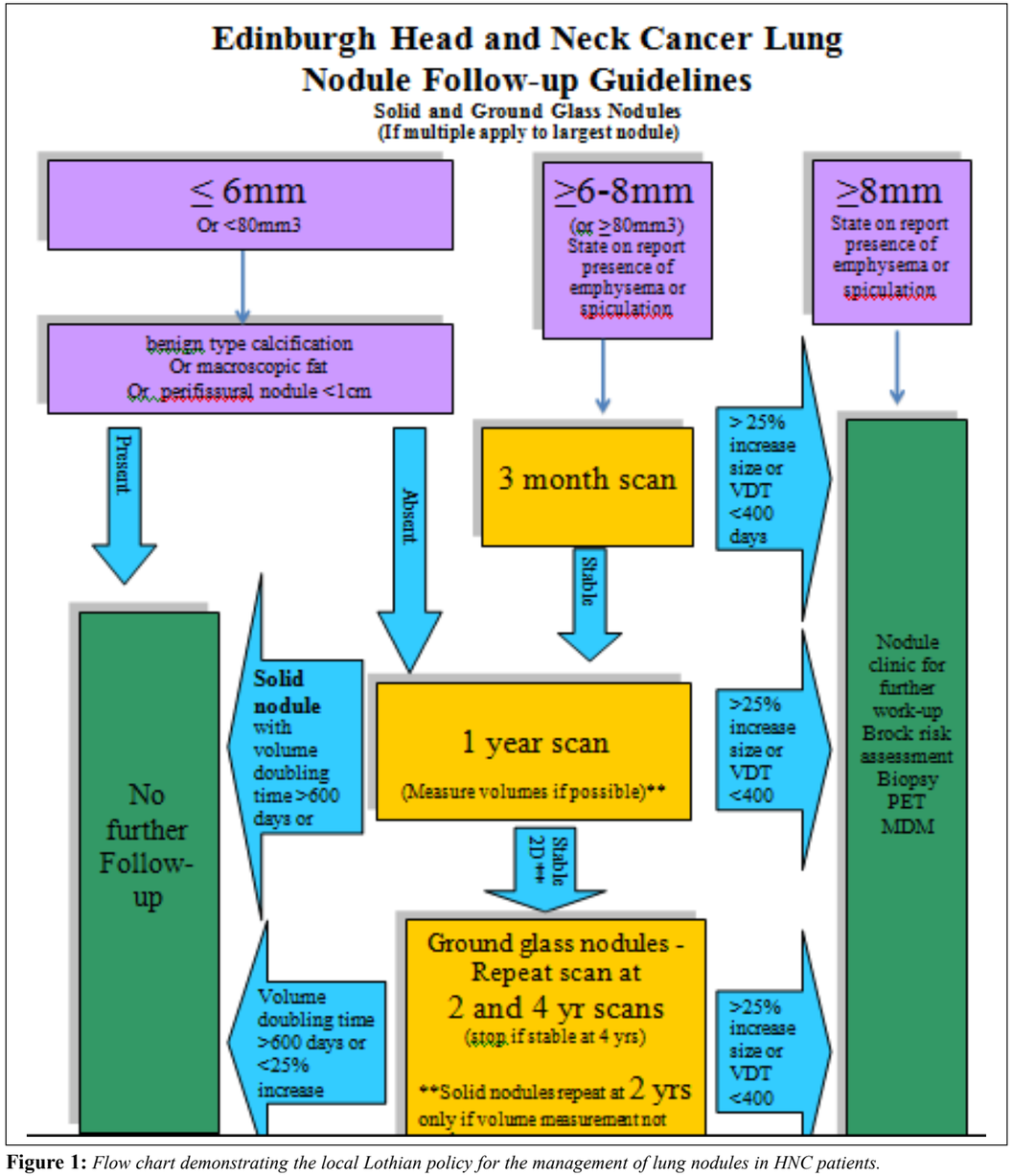

Figure 1: *Flow chart demonstrating the local Lothian policy for the management of lung nodules in HNC patients.*

size was associated with the risk of malignancy. The data showed that there is a significant risk even in the smaller nodules, likely due to there being two causes of malignant nodules to consider, metastasis and new lung primaries. If BTS guidance had been applied 117 smaller nodules would have been excluded however 5 (4.3%) were later shown to be malignant. All were confirmed as malignant within 12 months of initial detection.

More recent publications appear to show an increased risk of malignancy for the lung nodules in the head and neck cancer population. There is also a correlation between the stage of the disease and the likelihood of malignancy. There is therefore an argument contrary to the BTS guidance that for patients with HNC and pulmonary nodules, no matter the size, if the nodule is non-calcified, serial imaging should be considered[25].

Practical Application

For patients who have a small or indeterminate nodule and early stage HNC undergoing uni-modality treatment, interval imaging should be arranged following completion of initial treatment. The time to interval scan will be determined by the size of nodule in question as <6mm nodules rarely grow sufficiently fast to make re-imaging in less than 6 months worthwhile.

For those patients who require dual modality therapy, the treating team should consider re-assessing the chest between treatment phases, particularly for high volume nodules. If the nodules remain unchanged, treatment will continue as planned with an interval scan at 12 months. For those with evidence of progression, re-assessment of treatment goals is required before continuing with aggressive therapies in the presence of a second malignancy or metastatic disease[25].

Conclusion

Overall the risk of malignancy within the lung nodules of patients with HNC are low. However, in contrast to lung nodules in other patient groups, size is a poor predictor of malignancy. By appreciating the low but significant risk of malignancy within lung nodules in patients with HNC, clinical teams can plan treatment effectively and arrange interval imaging in order to tailor the goals of therapy to the individual case appropriately.

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Robotic surgery for head and neck cancer

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Abstract
Transoral robotic surgery (TORS) is a novel technique in the management of head and neck tumours. Head and neck cancer can be treated with either non-surgical or surgical means. Resective surgery has traditionally involved 'open' approaches with significant functional detriment to speech and swallow, amongst other side effects. TORS offers an enhanced operative experience with miniaturised wristed instruments and a magnified 3-dimensional endoscopic view, providing a minimally invasive surgical approach compared to open surgery. With the increasing incidence of high risk Human Papilloma Virus positive (HPV+) oropharyngeal cancer in a younger cohort of patients, whom once cured of cancer have longer to live with the side effects of radiation and concurrent chemotherapy treatment, TORS is an alternative primary treatment option in selected patients with similar oncological results and potentially better functional outcomes compared to non-surgical therapy. This in-depth review will cover the rationale for TORS and its application in the multidisciplinary management of head and neck cancer.

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Key words
Robotic surgery, TORS, head and neck cancer

Introduction
Head and neck cancer comprises a heterogenous group of tumours arising from various subsites of the head and neck region[1]. The vast majority originate from squamous epithelium of the upper aerodigestive tract, with head and neck squamous cell carcinoma (SCC) the 6th most common malignancy worldwide[1]. Dependent on stage of disease, head and neck cancer can be treated with either surgery +/- adjuvant (chemo)radiotherapy or upfront radiotherapy +/- concurrent chemotherapy (CRT)[1].

Surgery for head and neck cancer is based on well-established oncological principles of resecting the tumour with an appropriate margin of normal tissue, whilst also managing the neck with either an elective or therapeutic neck dissection[1]. Traditional open surgical approaches, which have been tried and tested for decades, require large incisions and invasive approaches to various parts of the upper aerodigestive tract, and whilst permitting en bloc resection of tumour with clear margins, result in significant post treatment functional impairment in speech and swallowing amongst other side effects. With the evolution of newer radiation delivery techniques for head and neck cancer, publication of phase III trials non-surgical trials promoting the organ preservation paradigm that reported comparable outcomes[2,3], there has been a shift over the past 20 years towards non-surgical treatment for most advanced head and neck cancers, with surgery reserved for salvage treatment.

Transoral microsurgery (TOLM) emerged as an alternative to open surgery for oropharyngeal, supraglottic and glottic tumours[4-6], providing the option of primary surgical treatment for head and neck cancer with reduced morbidity. However, despite TOLM providing excellent oncological control for certain head and neck subsites such as the oropharynx and supraglottis, the learning curve in gaining proficiency is steep[7], and there are technical limitations from operating in 2 dimensions with a laser cutting tool whose maneuverability is limited by line of sight. In addition, use of the laser frequently involves cutting through tumour to ascertain depth of disease, with further sampling to ensure clear margins, which is fraught with difficulty and controversy in assessing pathological margins[8].

Figure 1: *Robotic theatre set-up.*

Various types of active and passive surgical robots have been trialed, mainly by urologic and orthopaedic surgeons, in the 1980s and 90s, but the daVinci Surgical Robotic System (Intuitive Surgical Inc. Sunnyvale, California, USA) has been the only commercially available surgical robot since the early 2000s. Using this platform Weinstein et al reported the first transoral robotic surgical (TORS) series for the treatment of oropharyngeal cancer (OPC) in 2007[9].Unique advantages of the daVinci surgical robot include: an enhanced 3 dimensional (3D) endoscopic view with 10x magnification for the operating surgeon seated comfortably at the console (Fig. 1), miniature wristed instruments on a separate patient cart with a much wider range of movement compared to the human hand, elimination of tremor, and additional arms for retraction and suction via the patient side surgical assistant. To date the vast majority of robotic surgery for head and neck cancer has been done for the treatment of OPC; therefore, this review will focus predominantly on the role of TORS for oropharyngeal cancer.

Epidemiology of Oropharyngeal Cancer
The incidence of high risk human papillomavirus positive (HPV+) oropharyngeal cancer (OPC) is rising. There is good epidemiological data showing increased numbers of HPV-related oropharyngeal cancer around the world[10-12] (Table 1). While there has been a continued increase in the prevalence of HPV oropharyngeal cancer over time, a recent UK study[10] suggests this has plateaued. HPV+ OPC is predominately seen in younger men in their 5th decade[11], who have fewer co-morbidities compared to older cancer patients, enjoy a good prognosis and as such considerations regarding side effects of oncological treatment are particularly important. Therefore, in addition to cancer related outcomes, improved function and reduced toxicity have become key objectives in treating this group of patients.

Table 1. Prevalence (%) of HPV-positive oropharyngeal cancers around the world[12]

	Before 1995	1995–1999	2000–2004	2005–2015
Worldwide	32.3 (46.7–56.9)	37.0 (30.1–44.0)	51.8 (46.7–56.9)	52.9 (42.8–63.0)
North America	43.1 (28.8–57.4)	47.3 (31.3–63.3)	66.6 (59.0–74.2)	64.7 (48.0–81.4)
Europe	28.0 (18.2–37.7)	35.6 (26.5–44.7)	42.4 (35.6–49.1)	49.5 (36.4–62.6)

Justification for considering surgery as primary treatment modality for Oropharyngeal Cancers

HPV-Positive Squamous Cell Cancers
Several studies have shown that the radical doses of chemoradiotherapy (CRT) used to treat head and neck cancer (with the aim of organ preservation) cause significant patient morbidity in the short and long term. Whilst the use of radiotherapy with concomitant chemotherapy improves survival and locoregional control compared to radiotherapy alone[13,14], it also increases the burden of acute toxicity[15], with mucositis being one of the main acute symptoms. Trotti et al.[16] demonstrated in a systematic literature review, which included data from 6,181 patients, that 80% experienced significant mucositis, with resultant hospitalisation of 16%, and modification of radiotherapy regimes in 11%. Severe mucositis was higher with the use of altered fractionation protocols, compared to conventional radiotherapy[16].

We also know that acute radiation toxicities can persist into the long term, although this is often underreported or underestimated[17]. Machtay et al.[18] performed a meta-analysis of 230 patients included in 3 large trials (RTOG 91-11, RTOG 97-03 and RTOG 99-14) to investigate whether patients experienced toxicity over 6 months after radiotherapy treatment. Over 43% of patients who had no pre-treatment dysfunction, were found to have on-going grade 3 or higher toxicity and had continuing use of a gastrostomy tube for feeding or had died from a cause probably secondary to laryngeal dysfunction. Those with higher T stage, increasing age, or a primary tumour in the larynx or pharynx were most at risk of long-term toxicity. Long term dysphagia after CRT requiring permanent gastrostomy or nasogastric tube for nutrition is also a recognised side effect[19-21]. Despite improvements in the delivery of head and neck radiation treatment, such as

parotid-sparing intensity-modulated radiation therapy (IMRT)[22], one third of the patients experience grade 2 or worse xerostomia as assessed by the Late Effects of Normal Tissues Subjective-Objective Management Analytic (LENT-SOMA) measure. These long-term treatment related side effects, such as swallowing dysfunction and xerostomia, cannot be ignored, as functional outcomes after head and neck cancer therapy are a top priority for patients when making treatment decisions[23].

As HPV+ OPC tends to occur in a relatively younger patient cohort and the oncological outcomes are similar regardless of treatment modality (i.e. surgery versus radiotherapy), survivorship issues are a major concern. For patients receiving CRT, top priorities at various time points are consistently xerostomia and dysphagia[19], the former being a side effect seen with radiation therapy alone. Prospective observational studies suggest that the long-term radiation side effects of xerostomia and dysphagia could be avoided with a primary TORS approach. Results from an observational study[24] of 74 patients treated with TORS plus adjuvant therapy and 46 patients treated with definitive CRT, showed that primary TORS resulted in significantly better saliva-related quality of life compared to definitive CRT at 1, 6, 12, and 24 months ($p < 0.001$, $p = 0.035$, $p = 0.005$, $p = 0.007$). With gastrostomy tube use as a surrogate marker of poor swallowing, the retrospective matched cohort study of Sharma et al.[25] identified that patients who received TORS-based treatment had lower gastrostomy tube rates after surgery (risk reduction by 57%) over time. It is worth noting that gastrostomy tube prevalence decreased for both treatment groups, with 3% of gastrostomy patients in the TORS group and 11% in the non-surgical group[25]. Similar findings were identified in a systematic review involving 20 case series[26], including 8 IMRT studies (1,287 patients) and 12 TORS studies (772 patients). Whilst oncological outcomes were comparable between the two treatment groups, the adverse events profile was different: oesophageal stenosis (4.8%) and osteoradionecrosis (2.6%) for IMRT, haemorrhage (2.4%) and fistula (2.5%) for TORS.

Incorporation of TORS into the treatment plan allows clinicians to tailor adjuvant therapy in patients who would otherwise receive CRT as standard therapy. In a study of 76 patients who underwent TORS, Gildener-Leapman et al.[27] showed that up-front TORS de-intensified adjuvant therapy, with 76% of stage I/II and 46% of stage III/IV patients avoiding CRT. Conversely, the pathological staging from TORS resulted in 33% of patients who would have received radiotherapy alone based on clinical staging, being intensified to receive adjuvant CRT.

HPV-Negative Oropharyngeal Squamous Cell Cancers

These cancers typically have a worse prognosis compared to HPV+ squamous cell carcinoma[28]. All level I evidence for this group of patients supports primary non-surgical treatment. The French 94-01 phase III multicentre randomised trial[3] recruited 226 patients, comparing radiotherapy alone with CRT. Although explicit HPV testing was not performed, patient cohorts with large primary sites and low volume nodal disease is usually indicative of HPV-negative disease. They reported a 5-year overall survival (22.4 vs. 15.8% [$p = 0.05$]) and locoregional control (47.6 vs. 24.7% [p = 0.002]) favouring CRT. The RTOG 1221 study[29] was set up to evaluate primary transoral surgery (TORS or TLM) with adjuvant radiation versus primary radiation with concomitant chemotherapy in HPV-negative OPC. Due to poor accrual, this trial did not reach completion.

Other prospective data sets where HPV-negative cancers have been treated by TORS and adjuvant radiation indicate high control rates, from 80 to 94%[30-32], however, these studies may be subject to selection bias in that patients with advanced disease not amenable for TORS are more likely to be treated with CRT. A UK-led randomized trial for this group of patients with a surgical arm is ongoing (CompARE; UKCRN 18621)[33].

A small number of prospective studies have shown that adding surgery to the treatment of patients with HPV-negative oropharyngeal cancer offers better control rates[34]. As discussed above, the morbidity and mortality rates attributed to open surgery[2] do not apply to current surgical practice, and especially to transoral surgery; data on 30-day mortality from the UK national head and neck database indicates a mortality of less than 1%[35].

Non-Squamous Cell Oropharyngeal Cancers

Minor salivary gland tumours are the most common non-squamous cell cancers found in the oropharynx. Surgery is the primary management option. Following careful clinical assessment, and if surgical access is adequate, transoral resection with or without adjuvant radiation offers equivalent control rates with less disruption of anatomy, and thus earlier postoperative recovery[36].

TORS for Tonsil and Base of Tongue Cancers

Tonsil Cancer

The principle of TORS surgery is en bloc resection with a histologically clear margin. The foundations for en bloc resection of tonsil cancers via the transoral route were established in the 1950s when Huet[37] first described the procedure that is widely known as a radical tonsillectomy or lateral oropharyngectomy. This involved transoral resection of the tonsil and superior constrictor muscle deep to the parapharyngeal space. Holsinger et al.[38] reported good oncological outcomes for tonsil cancers using this technique. En bloc resection of the tonsil, although feasible with the TOLM approach, is not easy due to limitations from line of sight working and instrumentation. The advent of TORS has allowed surgeons to perform en bloc resections at this primary site with relative ease. Superior optics and maneuverability, combined with the ergonomics, have meant that the learning curve for transoral robotic radical tonsillectomy is significantly less compared to that for TOLM[39].

TORS radical tonsillectomy is one of the first procedures undertaken by surgeons in the early stages of their TORS practice. The first report of TORS radical tonsillectomy in 2007 by Weinstein et al.[9] included a cohort of 27 adult patients with stage T1 – T3 tonsil tumours. Weinstein et al. reported a negative margin rate of 93%, 0% mortality, and an acceptable complication rate with 4% gastrostomy tube dependence at 6 months. Similar high local control rates have been replicated in several single-centre series, and a multicentre review plus systematic review have confirmed the oncological robustness of TORS radical tonsillectomy.

A global multi-institutional study[30] that collated outcomes for 410 patients from 11 centres, demonstrated 2-year locoregional control rates of 92% and disease-free survival of 91%. A meta-analysis[26] comparing TORS, neck dissection +/- adjuvant therapy (IMRT +/- chemotherapy), and salvage surgery, identified 20 case series. The data from 772 surgical patients were compared with 1,287 patients receiving primary non-surgical treatment, and oncological outcomes were comparable (2-year overall survival estimates ranged from 84 to 96% for IMRT, and from 82 to 94% for TORS). Tracheostomy tubes were required in 12% of patients at the time of surgery, but most patients were decannulated prior to discharge.

TORS is currently used and approved by the United States of America (USA) Federal Drugs Administration (FDA), for T^1 and T^2 oropharyngeal cancers. The multi-institutional series described above reflected data from other publications in which TORS is performed primarily for early stage OPC, although a small proportion of T3 and T4 tumours were also included[26].

The TORS technique for tonsil cancer involves compartmental resection of the tonsil and underlying superior constrictor muscle, together with a cuff of soft palate and tongue base, whilst aiming for histologically negative margins. This procedure has been well described[9], and the key operative steps involved are:

- incision through the pterygomandibular raphe to identify the parapharyngeal space with the aid of the medial pterygoid muscle tendon,
- separating the constrictor muscles from the parapharyngeal fat and mobilising the superior pole of the tonsil with an adequate cuff of tissue from the soft palate,
- progressive dissection in the parapharyngeal space to free the stylopharyngeus and pharyngeal constrictors, mobilising tongue base mucosa and deep tissue between the anterior and posterior tonsillar pillars,
- resecting at least a centimetre segment of styloglossus to ensure a histologically negative margin,
- making index cuts on the posterior pharyngeal wall to avoid resection of excessive amounts of mucosa and progressive transection of the constrictor muscle along with the stylopharyngeal musculature to achieve an en bloc resection.

While some authors recommend suturing the posterior pharyngeal wall to the posterior aspect of the soft palate to avoid nasal regurgitation, the authors have not specifically found this to be an issue. Postoperatively the tonsil defect (Fig. 2) is left to heal by secondary intention, and complete mucosalisation normally takes place within 6 weeks. Patients commence oral diet well in advance of this and are usually free of nasogastric feeds within days[40].

Base of Tongue Cancers

TORS is also used to treat early stage (T1 and T2) tongue base cancers, however these tumours are less common and

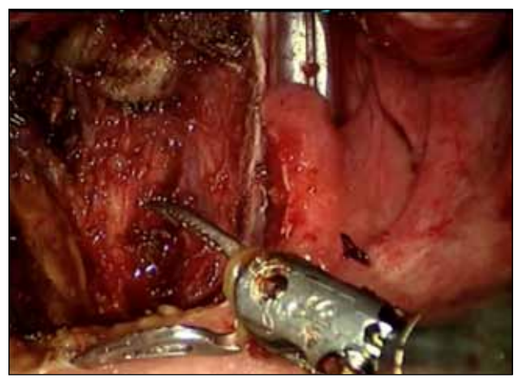

Figure 2: *Clinical photograph of the defect following lateral oropharyngectomy.*

the majority of published data includes this site together with tonsil tumours. The principles of surgery are similar to tonsil cancers, where again en bloc resection is performed. Adequate exposure of the tongue base tumour with appropriate retractors is essential, and the choice of retractor is determined by the patient's anatomy and ease of access. Careful pre-operative assessment of cross sectional imaging is vital to assess the precise location and lateralisation of the tumour. Tumours crossing the midline are not good candidates for TORS.

TORS base of tongue resection commences with an incision along the posterior one third of the tongue. This is deepened and followed by a midline cut towards the vallecula. The vallecula identifies the depth of resection required, and the lateral margin is established. This may involve part of the lower third of the tonsil. With progressive dissection, the lingual artery will be encountered. The bedside assistant can control bleeding from this vessel with ligaclips applied transorally. If the defect needs to be sampled, this is inked on table prior to excision to allow differentiation between the superficial and deep surfaces and orientated for the pathologist. Our practice is to place a nasogastric tube routinely in all patients and the timing of removal is dependent on recovery of swallowing function as judged by the rehabilitation experts.

Primary Tumour Margin Assessment.

One of the controversies with primary TORS in the management of OPC, is the ability to achieve negative margins post resection, given the anatomical constraints of that region. Positive margins are an indication for intensified adjuvant therapy with CRT[41,42] exposing patients to additional treatment related morbidity, and is also associated with local failure and adverse oncological outcomes in head and neck cancer patients[43]. Hence, the importance of a coherent approach to margin assessment and management by individual MDTs cannot be overstated.

There are two methods for the assessment of margins in transoral surgery: "specimen-driven" and "defect-driven." A defect-driven approach is commonly used in transoral laser surgery for non-glottic cancers. Here the ability to define the interface between tumour tissue and normal tissue allows for a tailored resection of the tumour and can be followed by sampling of the tumour bed. However, this can lead to variable practices within MDTs when deciding whether adjuvant therapy is needed.

With TORS lateral oropharyngectomy, the superior access and maneuverability permits an en bloc resection and more comprehensive appraisal of the margins within the defect, after specimen resection. It is possible to sample the whole resection bed, frequently to a depth of several millimetres or more. In addition, the high-resolution video recording capabilities of the daVinci surgical robot allows the surgeon to easily communicate to the MDT completeness of macroscopic tumour resection.

The combination of a "specimen-driven" and "defect-driven" approach provides greater confidence in clear margins. However, critical anatomical structures, and boundary constraints will limit the ability to resect a wide margin, hence clear communication and clarity within individual MDTs on how to manage these situations is critical. Irrespective of the approach to margin assessment used, close communication between surgeon and pathologist is essential. While the current RCPath guidelines describe 5mm margins as being clear, this is very often not possible in OPC. However, many of the trials upon which treatment is being planned do not use 5mm and report on much smaller margins.

Management of the Neck in Oropharyngeal Cancer

Given the appreciable rate of microscopic nodal disease with OPC, neck dissection is an essential component of primary surgical management, even when there is no clinical or radiological evidence of cervical lymphadenopathy. The main debate with neck surgery and TORS is timing of neck dissection, i.e. staged at an earlier date before TORS, versus performed at the same time as TORS, versus staged and done at a later date following TORS. There are advantages and disadvantages for each approach, with the main proponents of staged neck dissection seeking to reduce the risk of pharyngocutaneous fistula, and maximise the allocated robotic theatre time available. However, there is currently no consensus on the best approach, but It is generally accepted that by performing neck dissection at the same time as TORS, individual branches of the external carotid artery (lingual, facial and ascending pharyngeal) may be identified and individually ligated, to reduce the risk of postoperative haemorrhage after transoral surgery[44,45].

Adjuvant treatment after TORS

Given the high oncological efficacy of primary radiation therapy or CRT for HPV+ OPC, there is considerable debate as to the value of primary surgery, even when less invasive surgery such as TORS is available. This debate is escalated further in situations when patients are exposed to trimodality therapy i.e. TORS and CRT.[27] Hence, it is essential and mandatory that prior to setting up a transoral robotic surgical practice, institutional agreement and protocols for surgical and radiation oncology treatment are agreed in advance for these patients.

Adjuvant radiation after TORS is determined by pathology assessment, with close margins, perineural or lymphovascular invasion some of the tumour factors used as criteria for adjuvant therapy. Primary site positive margins or nodal extracapsular spread are indications for adjuvant CRT. However, several prospective data sets have questioned the value of concurrent CRT in the adjuvant setting for HPV-positive tumours[46,47], and de-intensification regimes are being tested in ongoing trials. Where such trials, e.g. PATHOS[48] are available, it is highly recommended that patients are recruited into them.

TORS for Carcinoma of Unknown Primary

Carcinoma of unknown primary (CUP) comprises approximately 1–5% of all head and neck malignancies[49-51]. These patients present with cervical lymphadenopathy that is biopsy proven for carcinoma, but no obvious primary tumour is identified following thorough clinical examination and appropriate investigations. Of these unknown primaries, over 90% represent SCC, with adenocarcinoma, melanoma, and rarer histological subtypes making up the rest[52].

The majority of these cancers are small (<1 cm) tumours arising in Waldeyer's ring, i.e. lymphoid tissue of the nasopharynx, tonsil, and base of tongue[53], particularly in the oropharyngeal region, and especially amongst patients who are HPV+54-56. Even with advanced diagnostic workup the primary tumour location remains unknown in over 40% of cases[57-59].

The natural history of CUP is unclear, making diagnosis and management planning particularly difficult in these cases. Identification of the primary tumour is highly desirable as allows the patient to receive site-specific treatment, avoids wide-field radiation side effects[60], or the additional morbidity associated with surgical intervention, and is associated with better oncological outcomes[61].

PET-CT is widely used in the evaluation of head and neck CUP and is now accepted as a key component of the diagnostic protocol, performed prior to panendoscopy and permitting targeted biopsy of suspicious lesions. PET-CT provides additional primary tumour detection rates over conventional imaging techniques of between 37%[62] and 44%63 with a sensitivity of up to 97% and low specificity of 68%[63]. However, FDG-PET-CT is limited by its inability to detect small (sub-centimetre) tumours[64,65], and normal physiological tracer uptake by tissues such as salivary glands, lymphoid tissue, and muscle can result in a high false-positive rate, or false-negative result in situations where pathological 18F-FDG uptake is considered physiological[64].

The systematic review by Fu et al.[66] demonstrates the incremental benefit of lingual tonsillectomy by TOLM or TORS in the detection of occult primary head and neck SCC when the comprehensive diagnostic workup of clinical examination, cross-sectional imaging, PET-CT and panendoscopy + tonsillectomy +/- blind biopsies does not identify the primary tumour. From the 8 studies (2 TOLM and 6 TORS) that met inclusion criteria for subsequent analysis, lingual tonsillectomy provided incremental primary tumour detection in 72% of patients where no abnormal findings had been detected with comprehensive diagnostic assessment including PET-CT, examination under anaesthesia plus biopsies, and palatine tonsillectomy. In addition, contralateral tongue base carcinoma was identified in 6%[66] to 12%[67] of cases, supporting the need for bilateral tongue base lingual tonsillectomy as part of the comprehensive workup for CUP. As per bilateral palatine tonsillectomy, the additional morbidity from a contralateral lingual tonsillectomy needs to be considered. Overall morbidity from TOLM and TORS lingual tonsillectomy was low, with a 5% rate of post-operative haemorrhage as the main complication[66]. The systematic review by Fu et al.[66] is however limited by the small sample size of included studies, inter-institutional and inter-surgeon variation in the technique for performing TOLM or TORS lingual tonsillectomy, and publication bias, with institutions that have recorded favourable results more likely to publish their data.

Role of TORS in Recurrent Oropharyngeal Cancer

The standard of care for recurrent oropharyngeal cancers is open surgical resection. In selected cases, TORS has shown good oncological outcomes for this cohort of patients[68,69] Significant expertise with TORS is required prior to undertaking salvage TORS. Detailed pre-operative assessment of recent cross-sectional imaging and examination under anaesthesia to determine tumour extent, plus the use of adjuncts such as intraoral ultrasound to define tumour thickness and boundaries during TORS, are essential management components.

Post TORS Rehabilitation

A multidisciplinary approach is mandatory for these patients as all patients, particularly those with recurrent cancer, need careful pre-operative speech and swallow assessment. Appropriate feeding routes are decided based on this assessment. Speech and dysphagia rehabilitation vary significantly, and any intervention should be tailored to the individual's pre-existing dysfunction and consequent postoperative dysfunction. This includes a combination of dysphagia-specific strategies for the rehabilitation process[40].

Robotic surgery for other Head and Neck Cancer subsites

Nasopharyngeal Cancer

Radiotherapy with or without chemotherapy remains the gold standard treatment for nasopharyngeal cancer. Whilst loco-regional control has improved with non-surgical treatment over the years, local recurrence rates can be as high as 20% following CRT[70]. Nasopharyngectomy via TORS approach permits en bloc resection of selected recurrent tumours, with favourable outcomes[71]. However, the application of TORS to resection of nasopharyngeal tumours is still under evaluation, with current experience limited to cadaveric studies[72,73] or case reports[71]. TORS nasopharyngectomy is best performed by surgeons with considerable robotic surgery experience.

Laryngeal and Hypopharyngeal Cancer

TOLM procedures for laryngeal and hypopharyngeal cancers have been shown over the years to have favourable oncological and functional outcomes[5,6,74-76], and are an alternative 'organ-preserving' therapeutic approach compared to radiotherapy. TOLM is particularly suited for the larynx, with precision cutting via the CO2 laser, and the operating microscope permitting surgery in an anatomically constrained area.

Whilst TORS has been easily applied to oropharyngeal tumours, the daVinci surgical robot becomes less useful for surgical access in the distal pharynx and larynx. Retractors such as Feyh-Kastenbauer (FK) laryngeal retractor (Gyrus Medical Inc., Maple Grove, MN) have allowed the daVinci surgical robot to perform supraglottic laryngectomy, but the lack of CO^2 laser, bulkier, rigid instrument arms that clash as the working space becomes limited in the distal upper aerodigestive tract, make glottic and hypopharyngeal resections less feasible. The availability of newer flexible robots, such as the Medrobotics Flex Robotic System[77], and modifications to the daVinci, such as the single port (SP) system[78], may overcome these challenges.

Robotic surgery for laryngeal and hypopharyngeal cancer consists of four main procedures:

(a) supraglottic laryngectomy,
(b) total laryngectomy,
(c) glottic cordectomy
(d) partial pharyngectomy or hypopharyngectomy.

Prior to undertaking robotic laryngeal and hypopharyngeal surgery it is essential that the operating surgeon has an in-depth understanding of endoscopic head and neck anatomy[79]. Particular attention to the location of important neurovascular structures, such as the superior laryngeal vessels and nerve, lingual artery and vein, hypoglossal nerve, and common carotid artery is vital. Patient selection is also critical[80], as certain patient factors such as co-existing respiratory disease, and tumour factors such as paraglottic space involvement, would be contraindications to a minimally invasive surgery approach.

TORS supraglottic laryngectomy is the most common robotic laryngeal procedure performed to date. The operative technique[81] is similar to that for TOLM, which has been extensively described[76], and has been used to treat a variety of different tumours including SCC[82,83], haemagiomas[84], schwanommas[85], and atypical carcinoid tumours[86]. Data for oncological and functional outcomes is limited to a few cohort studies with small sample sizes, but the reported disease free survival rates of 91%[83] to 100%[87] for T1 – T3 tumours is excellent, whilst tracheostomy and gastrostomy tube dependence is also low.

TORS total laryngectomy is limited to a number of published case series[88-90], with the main aim of reducing the morbidity associated with open salvage total laryngectomy i.e. pharyngocutaneous fistula. In situations when a concurrent neck dissection is not required, TORS laryngectomy requires less soft tissue dissection and produces a much smaller pharyngotomy defect which can be repaired transorally with using the needle driver instrument of the daVinci robot. TORS total laryngectomy is a technically demanding procedure that requires the surgeon to acquire extensive head and neck robotic experience before undertaking the operation.

TORS glottic cordectomy has not gained prominence, given the anatomical and equipment constraints described above, and the established use of TOLM in this region. Some studies have demonstrated that TORS glottic cordectomy is feasible[91] and may provide better access compared to TOLM[92].

Hypopharynx SCC tends to present at an advanced stage, hence most patients are not suitable for a minimally invasive surgical approach, with primary CRT the favoured therapeutic option and surgery reserved for salvage. Despite limitations of access to the distal pharynx, some authors have demonstrated the feasibility and effectiveness of TORS partial pharyngectomy, or hypopharyngectomy in resecting small, stage T1 – T2, tumours[93-95]. Published data is scare, hence it is difficult to draw any comparisons on oncological outcomes with CRT.

Complications of Robotic Head and Neck Cancer Surgery

En bloc oropharyngeal resections with TORS has been shown to be safe by several studies. Although these publications do not report oropharyngeal cancer cohorts in isolation, the vast majority of patients had an oropharyngeal primary, hence the data is applicable to this group. In a systematic review involving 12 TORS studies with 772 patients[26], significant haemorrhage was reported in 2.4% and pharyngocutaneous fistula in 2.5%. A prospective review of 305 patients from the American College of Surgeons NSQIP data set, published after the systematic review above, Su et al.[96], identified a complication rate of 7.9% and a 30-day mortality of 0.7%, with increasing length of stay predominately related to pre-existing comorbidity. Single institution experience[97] show a trend of decreasing complications as robotic surgery experience increases over time, and older patients have a higher rate of complications.

Future Applications

Robotic surgery is here to stay. Whilst there is still debate as to its cost effectiveness given the expense associated with initial set-up, maintenance, and consumables, there is no doubt that this novel surgical technique is safe and offers excellent oncological and functional outcomes when used as the principal treatment modality for selected head and neck cancers. As alternative surgical robots to the daVinci system, such as the Medrobotics Flex Robotic System[77] and Senhance Surgical Robotic System (Transenterix, USA)[98] gain market share, this will undoubtedly drive down costs and promote innovation.

Additional benefits of robotic head and neck surgery that are still in the development phase include: augmented reality[99,100] where the ability to superimpose cross-sectional imaging over the console surgeon's endoscopic view of the operative field will promote safer surgery by facilitating the avoidance of critical neurovascular structures, whilst an improved rate of negative margins could be achieved with optical imaging using injected 'fluorophore conjugated antibodies' to specific tumour markers[101,102] and built in endoscopic filters within the robotic system, allowing the surgeon to visualise disease that would otherwise have remained 'hidden'. Finally, advances in the field of artificial intelligence[103] combined with the other benefits of robotic surgery, could revolutionise head and neck cancer surgery.

SUMMARY

Robotic head and neck surgery is a novel, safe, and effective procedure for treating selected head and neck cancer patients, in particular HPV+ OPC. Technological advances in robotic equipment, molecular biology, optical imaging, and artificial intelligence offer exciting prospects for the future. Several clinical trials are exploring the role of robotics in head and neck cancer and their results are expected to significantly change the management of head and neck cancer in the near future.

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The risk-benefit ratio of chemoradiation treatment in head and neck squamous cell carcinoma: value of extranodal spread and margin status

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Abstract
Application of chemoradiation treatment for head and neck squamous cell carcinoma (HNSCC) promises options for organ preservation and improved survival. However, chemoradiation is associated with a significant increase in side-effects compared to radiation alone. Studies in postoperative HNSCC suggest that the presence of extranodal spread and positive surgical margins may justify a choice for postoperative chemoradiation. In the present paper we summarize the strengths and weaknesses of the evidence this justification is based on. We conclude that the risk-benefit ratio of chemoradiation treatment for HNSCC is suboptimal and needs further improvement.

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Key words
Head and neck cancer, extranodal extension, surgical margins, outcomes

Introduction
Head and neck squamous cell carcinoma (HNSCC) includes a diverse collection of malignancies. These share a common derivation from the upper aerodigestive tract mucosa, under the influence of an array of intrinsic (genetic) and extrinsic (tobacco, alcohol, HPV) causative factors[1]. The resultant nature of HNSCC is highly variable, unpredictable, and (potentially) aggressive, with a large proportion of patients presenting with advanced stage disease. Although aggressive treatment is often required, this is complicated by the anatomically dense and functionally important head and neck region and substantial comorbidity that typify affected patients. These features do not allow much room for therapeutic experimentation, as the balance between the grave consequences of undertreatment, and unnecessary side effects of overtreatment is understandably precarious[2].

Few scenarios illustrate the divide between such competing clinical interests better than the consideration of chemoradiation therapy in the management of HNSCC. On the one hand, the advent of chemoradiation has rendered clear benefits. For example, primary chemoradiation offers the potential for organ preservation without survival compromise in the setting of advanced, but operable HNSCC. This avoids debilitating surgical resections, and offers functional preservation in a significant proportion of patients. Chemoradiation also has the ability to improve outcome by approximately 5-8% compared to radiation alone, in the adjuvant setting, or in cases of inoperable HNSCC.[3] However, chemoradiation is associated with significant side effects. Compared to the modest 5-8% survival benefit over radiation alone, chemoradiation doubles the risk of grade 3/4 toxicity from 25% to 50%[3,4]. In other words, the number needed to treat (NNT) accounts to approximately 20, while the number needed to harm (NNH) is only 2-3. It is clear from comparing these numbers that the risk-benefit ratio of chemoradiation therapy is out of balance which an obvious cause for concern and debate[2].

The present paper discusses the value of extranodal extension (ENE) and surgical margin status in optimization of the risk-benefit ratio of chemoradiation application in HNSCC.

Extranodal extension
The presence of lymphatic metastasis is an important prognostic factor in HSCC, with its presence associated with a 50% reduction in survival[5]. Among patients with lymphatic metastasis, risk can be categorized further based on the size, number, laterality, proportions and location of the affected lymph nodes[6]. However, the most ominous nodal hallmark of reduced clinic outcome is ENE[5].

ENE is defined as extension of metastatic tumor deposits through the lymph node capsule. The incidence of ENE in metastatic neck dissection specimens is approximately 50%[2]. Accumulating evidence suggests that ENE is associated with suboptimal treatment outcomes. Rough estimates depict that ENE is associated with a three-fold increased risk of regional relapse and a two-fold increased risk of distant metastasis[7]. A meta-analysis of 1620 patients by Dunne et al suggests 5 year survival of 58.1% for ENE negative patients, compared to 30.7% for ENE positive patients, with an odds ratio of 2.7. The authors concluded that ENE is related to a 50% drop in the 5y survival rate for a given TNM stage[8].

Significant debate surrounds the question whether ENE is an independent predictor of outcome. Although some support this relationship[9,10], several studies failed to attribute independent prognostic significance[11,12]. Several observations may explain this discrepancy. Firstly, the presence of ENE is strongly associated with other nodal prognostic factors. For example, Woolgar et al demonstrated that the incidence of ENE increased with increasing size of lymph nodes and/or metastatic deposits, increasing number of involved lymph nodes, presence of contralateral metastases (relative to primary tumor), proportion of involved nodes (relative to surgical nodal yield), and location of diseased nodes in more caudally located neck levels.[13] Non-comprehensive inclusion of such factors in multivariate models accounts at least in part for the observed discrepancy. The same accounts for the presence or absence of Human Papilloma Virus (HPV) infection, which affects prognosis of oropharyngeal squamous cell carcinomas in a notoriously ENE-independent fashion[14].

A second complicating issue is represented by non-uniformity of histopathological definitions. Although there is little argument over overt extracapsular tumor extension or clear intraglandular disease containment, discrepancy reaches its zenith in cases where the invasive tumor front resides in close proximity to the (perceived) lymph node capsule, or scenarios where capsular identification is hampered. This may include, but is not limited to cases in which the tumor deposit is located within the nodal hilum area (which lacks a capsule), capsular breach is incomplete, the capsule is discontinuous, or cases in which a desmoplastic immune response surrounds and mimicks the lymph node capsule. These are issues which have hampered establishment of clear histopathological criteria for ENE and continue to contribute to a significant degree of intra- and inter-observer variability in the assessment of ENE[15]. The net result of such ambiguity may be an urge for overdiagnosis among pathologists fueled by concerns over the putative implications of treatment inadequacy in the case of a missed ECS diagnosis.

A third contributory factor pertains to grading of ENE extent, which although associated with prognosis, has been hampered by non-uniform criteria. Some studies suggest that macroscopically visible ENE carries more prognostic significance then microscopically visible ENE[16-18]. Lewis and colleagues proposed grading ENE into grade 0 (no ENE), grade 1 (tumour reaching the capsule without actual extension through), grade 2 (ENE < I mm beyond the capsule), grade 3 (ENE > 1 mm beyond the capsule), grade 4 (soft tissue metastasis without attendant lymphatic structure) and found that only grade 4 was associated with a statistically significant worse outcome.[19] Greenberg and colleagues reported absence of prognostic significance when comparing patients with ENE extent < 2mm compared to ENE extent > 2mm[20]. These analyses share an aim to quantify the extent at which ENE has clinical relevance (as an independent prognostic factor). However their use of predefined cut-offs also lacks an empiric approach to the problem, which may explain variability in study results. A recent study by Wreesmann et al sought to objectify this issue in a more empirical fashion[5]. Based on this work, ENE extent has been included into the 8th edition of the TNM system, at a generic cut-off of 2mm[21].

Altogether, the issues above continue to fuel debate. This has cast doubt on whether ENE is a truly intrinsic expression of aggressive tumour biology, or rather a meaningless epiphenomenon of advanced nodal disease. This continued debate is sustained by unavailability of an objective and widely accepted definition of clinically relevant ENE.

Surgical margins
Surgery remains a central backbone of HNSCC treatment, and its desired outcome is removal of all cancer cells from the surgical field. This aim is limited by the anatomically dense and functionally important anatomy within the head and neck region, as it competes with the goal to preserve the non-affected normal tissues for optimal functional and cosmetic outcomes. Persistence of cancer cells within the surgical field increases the risk of local recurrence in a linear fashion[22]. This is not only due to the mere presence of cancer cells postoperatively, but also to their increased chances of survival in the growth factor-enriched but

hypoxic postoperative wound bed. Postoperative tumor persistence also serves as an indirect reflection of aggressive tumor biology, as it is often associated with poor prognostic factors (high stage, perineural invasion, infiltrative growth pattern) which complicate successful removal[23].

Histopathological examination provides a suboptimal estimate of postoperative tumor persistence. A distance of 5mm (or more) between the invasive tumor front and resection margin is designated as a negative margin, and uniformly accepted as a threshold at which the risk of tumor persistence and associated tumor recurrence reaches an acceptable range. Anderson and colleagues conducted a meta-analysis which showed that margins less than 5mm have a significantly higher chance of recurrence and should dictate further treatment[24]. A distance between 1-5mm is deemed a close margin, while a positive margin is diagnosed when tumor cells are present within 1mm of the specimen rim, according to the Royal College of Pathologists[22].

The prognostic significance of margins status has been subject of multiple, predominantly retrospective studies.[22,23,25] For example, positive margin status was found to be associated with a dramatic increase in risk of local recurrence and decrease in disease-specific survival[22]. A study by Sutton and colleagues on 200 oral tongue cancer patients suggested that risk of local recurrence is increased almost 5-fold in the case of a positive margin (12% versus 55%), with a more than 7-fold decreased in 5y disease specific survival (11% versus 77%)[26]. Although the independent prognostic value of positive margins is universally accepted across the scientific community, this is less well supported for close margins. This is partly due to variability in its definitions, and the slightly arbitrary selection of the 5mm cut-off, which is not supported by sufficiently convincing evidence. For example, empirical analysis of the margin cut-off suggests that a clinically more relevant cut-off between close and negative margins is located close to 2mm distance. Additional confusion is created by the inadequate correction for associated poor prognostic factors through multivariate analysis. Altogether, these issues compound upon the already tenuous basis of margin assessment where significant variability may be introduced at different levels of the analytic process, including the surgical collection, handling, orientation, tissue processing, and microscopic assessment, which remains difficult to standardize[2].

Markers of chemoradiation benefit

Although retrospective studies suggest that clinicopathological factors such as ENE and suboptimal margins could serve as markers of HNSCC with a higher risk of recurrence and mortality, the ambiguity described above questions their validity as convincing indicators for benefit of treatment intensification. For this reason, several prospectively randomized trials were organized to study this issue. Unfortunately, these studies demonstrate significant variation as well. A trial by Laramore et al compared low-risk HNSCC (clear margins, no ENE) to high-risk HNSCC (ENE or positive margins). The study showed that high-risk HNSCC benefited from chemotherapy addition to postoperative radiation therapy. However, only margin status was a significant predictor of outcome, while ENE was not[27]. Subsequent studies from MD Anderson Cancer Center by Peters and Ang published presented similar comparisons of high and low-risk HNSCC based on margins, ENE and other factors. Randomization for different adjuvant treatment intensities revealed benefit in the case of high-risk HNSCC, and ECS rather than margins as a predictor of this effect[28,29]. Some of this heterogeneity was resolved by two subsequent trials, both of which included high-risk HNSCC only, and randomized patients to PORT with or without chemotherapy. Although both trials defined high-risk HNSCC using different clinicopathological factors, ENE and suboptimal margins were defining factors shared by these studies. The original publication of both trials revealed that outcome was improved by approximately 5-8% when chemotherapy was added to PORT[3,4]. A retrospective post-hoc analysis of data from both trials combined revealed that this benefit was only observed in cases characterized by ENE, positive margins or both[30]. These trials suggest that the observed benefits of chemotherapy addition to PORT in post-surgical HNSCC patients with ENE or positive surgical margins translates into a number needed to treat of approximately[20].

Limitations of evidence

Since publication of the EORTC22931 and RTOG9501 trials, recommendations and guidelines with regard to adjuvant treatment of HNSCC have been dominated by the conclusions of these trials and their combined data analysis (fig. 1 and 2). This has led to a universal recommendation of chemotherapy addition to PORT in postsurgical HNSCC patients exhibiting ENE and/or positive surgical margins, which has been included in the vast majority of guidelines. The resultant increase in post-operative chemoradiation application has rendered an increased understanding of treatment-associated complications and long-term side effects. It is now firmly established that addition of chemotherapy to PORT doubles the risk of grade 3/4 complications, from approximately 25% to 50%. This translates into a NNH of approximately 3.2 This may be viewed as a conservative

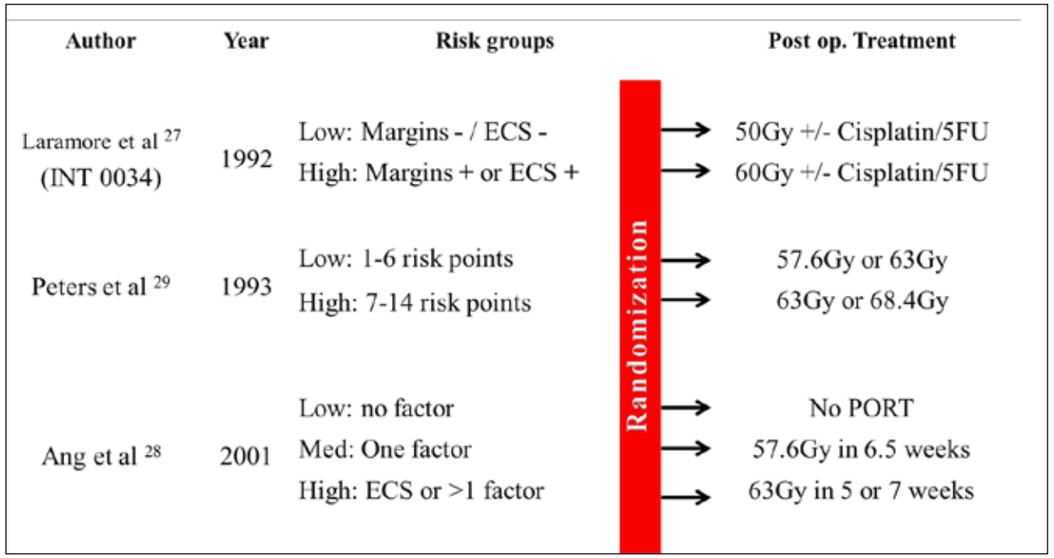

Figure 1: *Global outline of available randomized controlled trials aimed to study the relationship between risk factors and treatment intensity in HNSCC.*

estimate, as long term toxicity, such as fibrosis of masticator, laryngopharyngeal and esophageal muscles and nerves continue to accumulate over time.

The significant imbalance between the NNT and NNH of adjuvant chemoradiation treatment of HNSCC has fueled critical revision of the evidence supporting it. Over the years, criticism has mounted with regard to the generalizability and validity of the findings rendered by these postoperative chemoradiation trials. Concerns surround their inclusion profile, which included a predominance of laryngeal, hypopharyngeal and oropharyngeal SCC, which are most commonly treated by non-surgical means. In contrast, oral cavity SCC, favored to be treated with a surgical approach, represented a minority within the study population. Also, the HPV status of the oropharyngeal carcinomas, a marker of chemoradiation sensitivity independent of ENE status, remains unaccounted for in the data analysis. However, the most pertinent criticism surrounds the lack of multivariate confirmation of the prognostic role of ENE and margin status. This omission failed to rule out potential confounders of the findings, as both trials included a differential array of risk factors with variable associations to the presence or absence of ENE and/or margin status. A pertinent example includes the 57% of EORTC and 94% of RTOG patients characterized by advanced N2/N3 neck disease. Absence of multivariate correction for this possible confounder leaves it unclear whether the observed outcome effect associated with ENE and or margin status is independent of such nodal volume parameters including number, size and location of involved lymph nodes. This argument is strengthened by recent data suggesting that patients without ECS and positive margins experience significant benefit from adjuvant chemoradiation treatment, especially in the presence of advanced nodal stage.[31] Altogether, these findings undermine the basis of chemoradiation addition based on ECS and/or margin status alone, which is especially poignant information in the setting of low-stage HNSCC with ENE/positive margins, or high-stage patients without ENE/positive margins.

Conclusion

Chemoradiation treatment has greatly influenced the management of advanced HNSCC. However, the risk-benefit ratio of this treatment is a concern, as the NNH greatly outweighs the NNT. Since 2004, ENE and surgical margin status have been widely used as markers to help select patients that may benefit from chemoradiation, and thereby improve this risk-benefit ratio. However, the data underlying this practice are ambiguous and not supported by rigorous statistical analysis. Patients with advanced HNSCC are often focused upon cure, and willing to sacrifice. In the case of chemoradiation consideration, physicians involved in the care of these patients should thoroughly depict the current risk-benefit balance of this

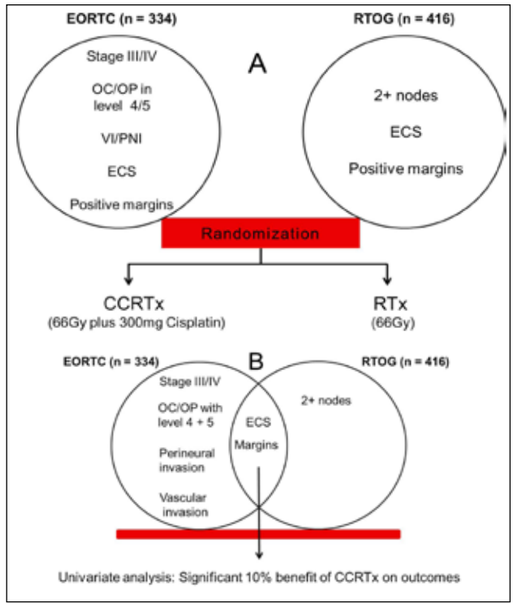

Figure 1: *Global outline of available randomized controlled trials aimed to study the relationship between risk factors and treatment intensity in HNSCC.*

treatment, and the lack of convincing benefit markers, in order to help patients take a balanced decision.

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An analysis of 302 minimally invasive parathyroidectomy patients over a 12-year period – is day-case surgery safe?

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Abstract

Purpose
Traditionally, a bilateral neck parathyroid exploration has been the standard treatment for primary hyperparathyroidism (pHPT) due to parathyroid adenoma. This usually requires a hospital inpatient stay. However, with the help of imaging, minimally invasive parathyroidectomy (MIP) has an excellent cure rate and minimal morbidity. The aims of this study are to investigate the accuracy of pre-operative radiological localisation in relation to operative findings, demonstrate the safety and efficacy of open-MIP (O-MIP) and show that this can be safely carried out as a day-case procedure. A review of the literature is also performed.

Methods
A retrospective review of 302 consecutive patients who underwent O-MIP for pHPT due to solitary parathyroid adenoma (April 2006 - March 2018) was performed. All patients were initially investigated by an endocrinologist to confirm pHPT and had pre-operative localisation imaging using ultrasound scan and 99mTc-sestamibi.

Results
79%(n=239) were female and 21%(n=63) male. 81%(n=245) had concordant pre-operative USS and MIBI scans. When the scans were concordant, there was 98%(239/245) identification of parathyroid tissue confirmed by intra-operative frozen section. Overall, 94%(n=285) had parathyroid tissue confirmed by intra-operative frozen section. Mean operative time was 61 minutes.

Analysis of results show increasing trend of performing this procedure as day-case: 26% (14/53) were day-case from 2006 to 2009, 62% day-case (73/118) from 2010 to 2013 and 98% day-case (128/131) from 2014-2018.

There were no re-admissions due to hypocalcaemia, recurrent laryngeal nerve injury or wound haematoma.

Conclusion
O-MIP can be performed safely as daycase. Accurate localisation is the key to successful O-MIP.

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Key words
“Hyperparathyroidism”, “Daycase”, “Parathyroid”, “Minimal Access Surgery” and “Minimally Invasive Parathyroidectomy”

Conflict of Interest
The authors declare that they have no conflict of interest.

Introduction
Primary hyperparathyroidism (pHPT) is the commonest cause of hypercalcaemia in the outpatient population. Primary hyperparathyroidism is usually caused by a solitary adenoma (80–85%), hyperplasia (10–15%), double adenoma (2–5%) or parathyroid carcinoma (<1%)[1]. Surgical treatment in the form of parathyroidectomy is the only definitive treatment of choice in the symptomatic patient, which has shown to improve health-related quality of life.[2,3]

In 1925, Mandel performed the first successful parathyroidectomy, and since then, traditional surgical practice has been the cervical incision with bilateral neck parathyroid exploration (BNE) approach.[4]

In the 1980s, due to advances in the preoperative localisation methods, new techniques were being described. These techniques include minimally invasive parathyroidectomy (MIP), minimally invasive radio-guided parathyroidectomy, video-assisted parathyroidectomy and endoscopic parathyroidectomy.[5]

Since then there has been plethora of studies that have described the technique and good outcomes of MIP.[6-26]

Conventionally, parathyroid surgery is done as an inpatient procedure. In 2000, the NHS Plan set a goal of increasing the proportion of elective procedures performed as day-cases as this would provide a means of helping the NHS to achieve its targets of treating more patients faster. Therefore day-case procedures are a key component of NHS modernisation. The Department of Health’s 2002 Day Surgery Operational Guide was then published as an aide to improve efficiency in day surgery units[27]. Day-case surgery is defined as admission and discharge on the same day for planned surgical procedures. Day-case procedures have a number of benefits, including patient preference for a shorter hospital stay, reduced risk of hospital-acquired infections as well as its financial benefits. The appropriateness of whether a procedure can be done as day-case depends on the preoperative patient assessment, the operation itself, the discharge plan, and postoperative support.

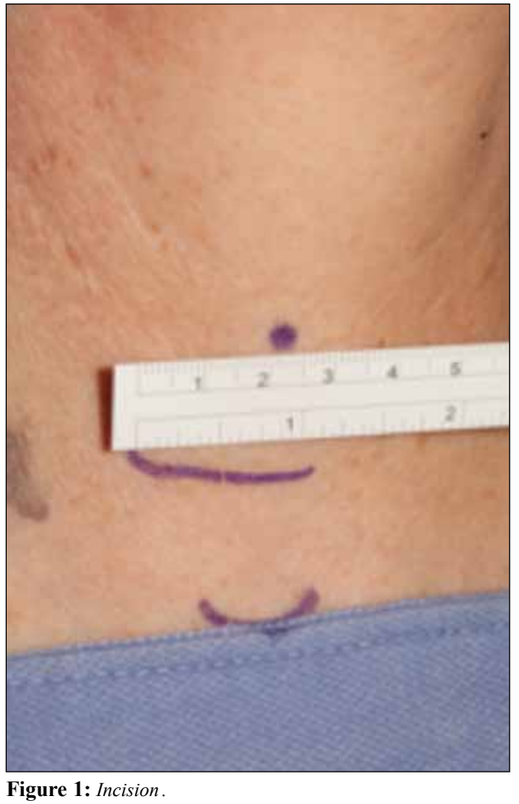

Figure 1: *Incision*.

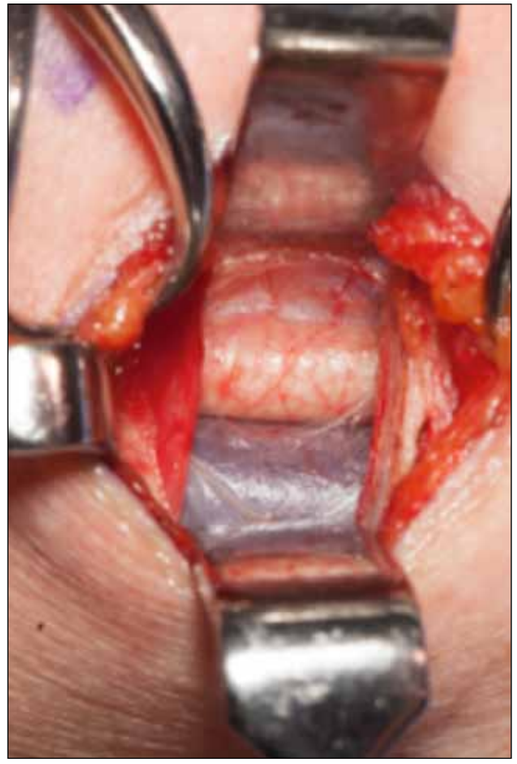

Figure 2: *Carotid Bundle.*

The specific post-operative risks of concern for parathyroidectomy include haemorrhage or bilateral recurrent laryngeal injury causing airway obstruction, and symptomatic hypocalcaemia causing tetany. However, with a technique such as open minimally invasive parathyroidectomy (O-MIP), the procedure can be performed using a small skin incision, sited over the suspected location of the adenoma based on the scans performed. This generally means that there is less tissue dissection, and because meticulous haemostasis is paramount for clear surgical field, the risk of post-operative haemorrhage causing airway obstruction should be lower. Also, with the help of pre-operative scans, O-MIP tends to be done unilaterally, which means bilateral recurrent laryngeal injury resulting in airway problems is rare.

There have been a small number of studies recently reported in the literature that have shown parathyroidectomy can be done safely as a day-case with an increasing trend in day-case parathyroidectomy[7,15,17,22,21,26,28]. Here we present our experience of 302 consecutive patients who

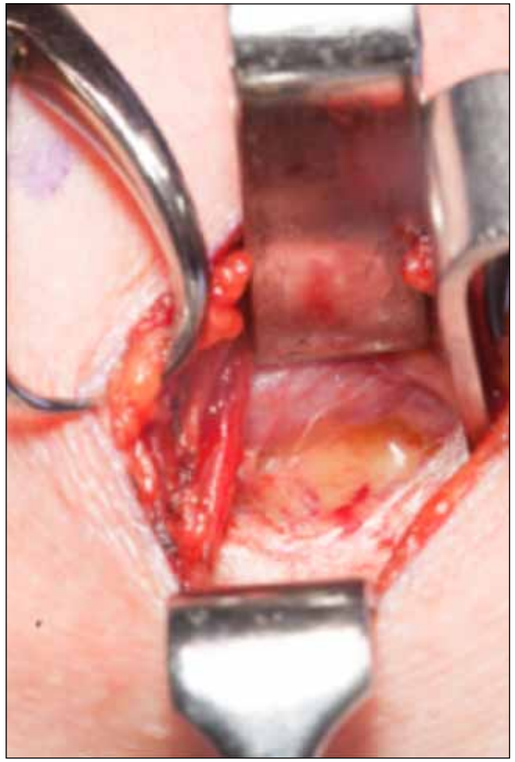

Figure 3: *Thyroid lobe rotated medially and parathyroid adenoma seen inferiorly.*

underwent O-MIP over a 12-year period in a single institution, the majority of which underwent day-case surgery.

Materials and Methods

A retrospective case notes review of 302 consecutive patients who underwent O-MIP from April 2006 to March 2018 was conducted. These were patients who underwent O-MIP for pHPT with pre-operative imaging suggestive of solitary adenoma.

Theatre database were used to identify patients' sex, age, date and duration of surgery. Patient records were reviewed for source of referral, pre-operative symptoms, pre-operative localisation imaging, operation findings, mode of anaesthesia, pre- and post-operative biochemical findings, and any complications encountered.

All patients were investigated initially by an endocrinologist to confirm the diagnosis of pHPT. Following this diagnosis all patients underwent radiological imaging using ultrasound (USS) with or without 99mTc-sestamibi scan (MIBI). The senior author performed all exploratory surgery electively and their admission was planned as a day-case procedure under general anaesthetic (GA) (unless specifically identified pre-operatively that inpatient procedure was required). Approximately 5% of patients were offered surgery under local anaesthetic (LA), either as a patient choice or due to multiple morbidities of the patient. LA involved deep cervical nerve block along with subcutaneous infiltration.

The surgical criteria for a day-case procedure were single adenoma. The patient must also have fit the agreed local protocols for patient assessment and these would include social and medical factors.

The main reasons for inpatient stay in this patient group would have included logistical reasons for patients travelling from out of region, significant co-morbidities or social circumstances such as having a responsible adult escort the patient home and provide support for the first 24 hours.

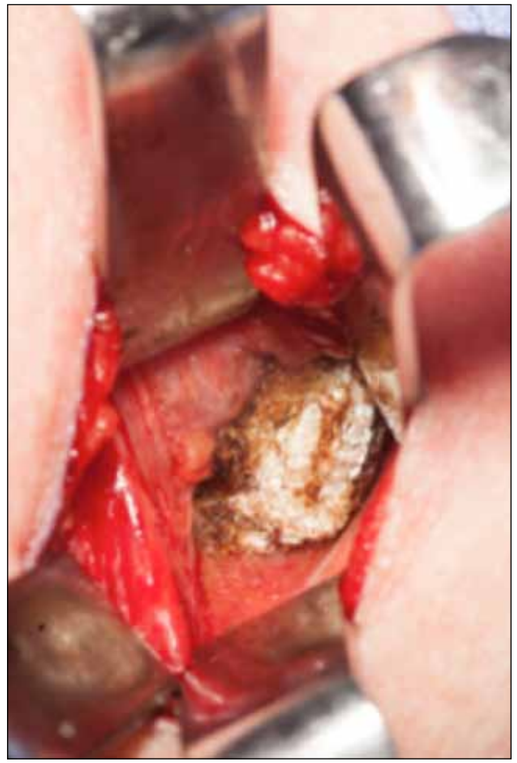

Figure 4: *Oxidized cellulose polymer in wound bed*

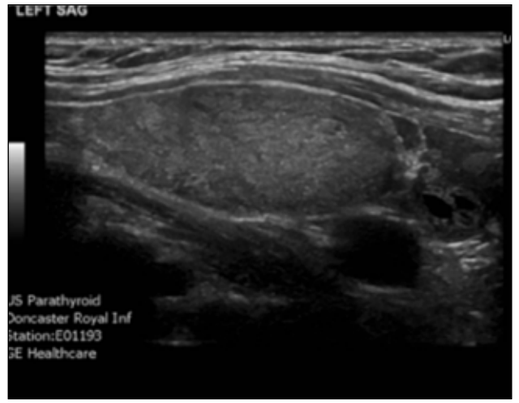

Figure 5: *USS showing left parathyroid adenona.*

O-MIP was performed using a 2– 2.5cm skin incision (Figure 1) sited over the suspected location of the adenoma based on the pre-operative scans. The carotid bundle is exposed by retracting the medial border of the sternocleidomastoid and lateral border of strap muscles (Figure 2). The thyroid lobe is rotated medially and the enlarged gland identified and excised (Figure 3).

Intra-operative frozen section was performed to confirm that parathyroid tissue had been removed. On confirmation a haemostatic agent made of an oxidized cellulose polymer was placed in the wound bed (Figure 4) and the skin wound was closed with an absorbable suture and the patient sent to recovery. Drains were not routinely used.

The first post-operative serum calcium and parathyroid hormone (PTH) levels were measured at 4-6 hours after the procedure. Patients were generally discharged the same day with a 1-week course of 1000mg oral calcium three times daily and 1 µg of alfacalcidol once daily. This was given to slow down the sudden drop of calcium levels and prevent post-operative hypocalcaemic symptoms. The patient was given a biochemistry request form and instructed to attend the hospital 3 days prior to the clinic appointment for serum calcium and PTH evaluation. An outpatient consultation was arranged 6 weeks post-operatively.

Results

Patient demographics

Out of the 302 patients identified, 239 were female and 63 were males (female to male ratio was 3.8:1). The mean age in years was 60 (standard deviation: 12.7) and median age was 61 (range: 18-91).

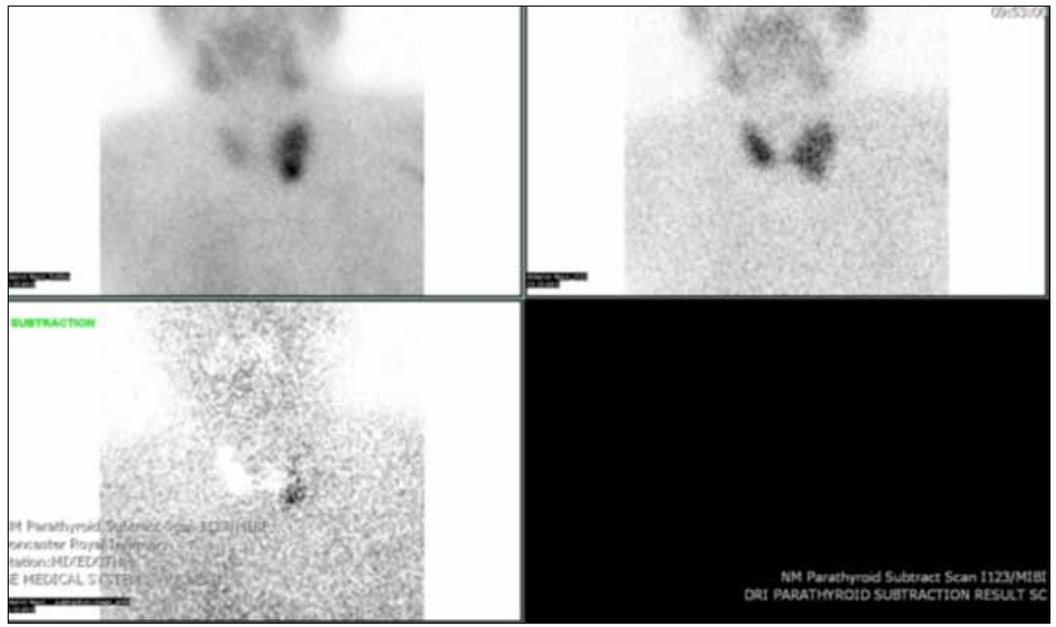

Figure 6: *MIBI substraction study showing left lower pole parathyroid adenoma.*

Symptoms

Majority of patients were asymptomatic and findings were incidental (171/302). 58/302 had musculoskeletal symptoms as their primary symptom; 47/302 presented with renal calculi; and the rest of patients presented with abdominal pain (13/302), psychological symptoms (10/302) and metabolic symptoms (3/302).

Pre-operative imaging and operative localisation concordance

Pre-operative USS and MIBI scans were concordant in 245/302 patients (81%) of cases. When the scans were concordant, there was 98% (239/245) identification of parathyroid tissue confirmed by intra-operative frozen section. Overall, 94% (285/302) had parathyroid tissue confirmed by intra-operative frozen section.

If the scans were not concordant, the senior author and the radiologist reviewed them together, and a clinical decision would be made on which side to explore first and in 84% (48/57) the adenoma was identified at final histology at first attempt. In 81% (46/57), intra-operative findings were in concordance with the USS scan localisation. In 11% (6/57), intra-operative findings were in concordance with MIBI scan. The senior author has also found that Single Proton Emission Computerized Tomography (SPECT) scan can be useful in gauging how posterior the adenoma might be.

Operative findings

In total, 5% (15/302) of patients underwent the procedure under LA. None of the LA cases required intra-operative conversion to GA. The mean operative time in minutes was 61.4 (Standard deviation: 24.7) and this included the waiting time for frozen section.

The commonest location where the adenoma was identified operatively was on the right at the lower pole of the thyroid (119/302). The second commonest location where the adenoma was identified operatively was on the left at the lower pole of the thyroid (105/302).

Biochemical tests

The mean pre-operative PTH level was 22.7 pmol/L and the mean post-operative (at follow up appointment) PTH level was 6.7 pmol/L (Paired t-test, $p< 0.0001$).

The mean pre-operative calcium level was 3.00 mmol/l and the mean post-operative (at follow up appointment) calcium level was 2.50 mmol/l (Paired t-test, $p< 0.0001$). Normocalcaemia was achieved in 95% (286/302) of patients.

Inpatient vs Daycase

Analysis of results show increasing trend of performing this procedure as day-case: 26% (14/53) were day-case from 2006 to 2009, 62% day-case (73/118) from 2010 to

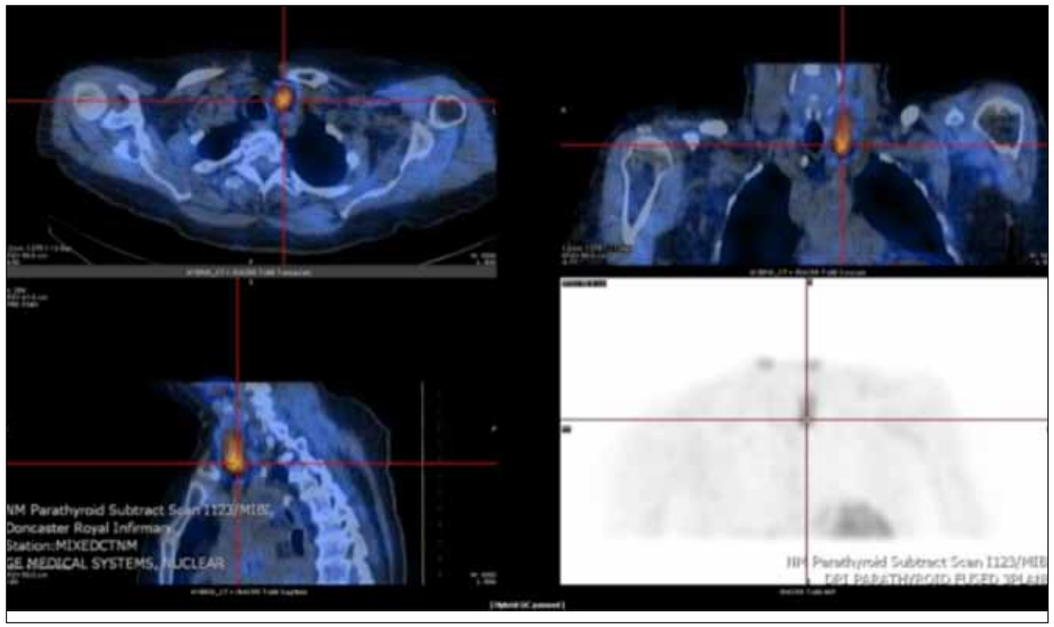

Figure 7: *SPECT scan showing left lower pole parathyroid adenoma.*

Table I. MIP Studies - Average hospital stay, percentage of day-case procedures, cure rate and complications

Study	Study size	Average hospital stay for MIP (days)	Day-case procedures (same day discharge)	Cure rate	Complications
Cohen et al 2005[7]	139 patients (US)	0.2	86%	99%	1 postoperative neck swelling
Carr et al 2006[9]	67 patients (UK)	Not reported	0%	97%	1 return to theatre for postoperative bleed
Pang et al 2007[13]	500 (Australia)	Not reported	Not reported	97%	3 permanent unilateral vocal cord palsy, 7 temporary unilateral vocal cord palsy, 3 haematoma (no operation), 2 reoperation for bleeding
Soon et al 2007[14]	349 patients in MIP group (Australia)	Not reported	Not reported	97%	3 temporary unilateral vocal cord palsy, 3 haematomas, 1 postoperative hypocalcemia, and 3 surgical site infections
Mihai et al 2007[15]	150 patients (UK)	Not reported (6 were admitted for 2–4 days)	49% (96% within 24 hours)	97%	3 temporary unilateral vocal cord palsy, 1 haematoma
Shindo et al 2008 local anaesthetic procedures[17]	186 patients (US)	Not reported	95%	100%	2 patients developed postoperative pneumothorax, 1 temporary unilateral vocal cord palsy, 1 wound haematoma managed conservatively
Kiminori et al[18] 2010	167 patients (Japan)	Not reported	Not reported	93-98%	1 temporary unilateral vocal cord palsy, 2 patients had postoperative bleeding that required reoperation
Hessman et al 2010[19]	75 in MIP group (Sweden and Denmark)	Not reported	0%	97%	4 haematoma, 1 postoperative wound infection, 1 permanent unilateral vocal cord palsy
Udelsman et al 2011[20]	1037 in MIP group (US)	0.2	85%	99%	0.77% Recurrent laryngeal nerve injury, 0.1% hypocalcaemia, 0.1% needed tracheostomy, 0.19% neck haematoma, 0.19% cerebral vascular accident, 0.1% pneumonia, 0.19% seizure
Parameswaran et al 2013[21]	86 patients (UK)	Not reported	93%	100%	Prolonged temporary hypocalcaemia following surgery was experienced in 2 patients, necessitating treatment (but not readmission)
Parameswaran et al 2014[22]	331 patients in MIP group (UK)	Not reported	66%	Not reported	Not reported specifically for MIP group, but for all parathyroidectomies (n=776) – 6 transient hypocalcaemia, 12 permanent hypocalcaemia, 3 wound infections
Chow et al 2015[23]	105 patients (Hong Kong)	Not reported	24%	98%	1 permanent unilateral vocal cord palsy, 2 temporary unilateral vocal cord palsy, 7 suffered temporary hypocalcaemia.
Joliat et al 2015[24]	118 patients in MIP group (Switzerland)	1	0%	95%	1 permanent unilateral vocal cord palsy, 3 temporary unilateral vocal cord palsy, 31 suffered temporary hypocalcaemia
Kay et al 2017[25]	119 patients in MIP group (US)	Not reported	Not reported	98%	Not reported
Sawant 2017[26]	59 patients (UK)	Not reported	90%	Not reported	No major complications

2013 and 98% day-case (128/131) from 2014-2018. Over 12 year period, 71% of cases were day case. Mean hospital stay was 0.3 days.

Complications

No patients developed post-operative hypocalcaemia requiring re-admission to hospital. There was no recurrent laryngeal nerve injury and no other significant complications such as pneumothorax, major vessel injury, wound haematoma or dehiscence.

Discussion

The benefits of MIP over BNE include shorter operative time, reduced complication rate, hospital length of stay and cost[29]. While BNE is of value in more complicated cases, the majority of solitary adenomas may be accurately localised and excised using a minimally invasive approach. The most-studied modalities for localisation are nuclear scintigraphy and sonography and these are commonly applied as initial studies. This paper shows that by utilising preoperative parathyroid localisation we can limit operative exploration. (Figure 5, Figure 6, Figure 7)

When the USS and MIBI scans were concordant, there was 98% intra-operative localisation. This series' operative findings of the common locations of parathyroid adenomas are in keeping with the literature – they are more commonly found in the lower pole positions[30].

In this study, 57 of the USS and MIBI scans were not concordant. 81% (46/57) of intra-operative findings was in concordance with the USS scan localisation. In comparison, 11% (6/57) of intra-operative findings were in concordance with MIBI scan. This series reveals that ultrasound in the hands of a radiologist with a special interest in parathyroid imaging has demonstrated to be a more reliable tool in accurate pre-operative localisation of the adenoma than MIBI –especially so in small adenomas or those with reduced oxyphil cells. All USS and MIBI scans were performed and reported by a single dedicated radiologist in this series. Ultrasound is superior to MIBI in demonstrating the surrounding anatomy. Identification of a polar feeding artery can discriminate parathyroid glands from lymph nodes, which usually have a hilar blood supply, often accomplished with a Doppler ultrasound scan. Furthermore, USS permits concomitant evaluation for thyroid pathology, in the presence of a cystic or multinodular thyroid; our practice is to perform intra-operative PTH to ensure that the adenoma has been removed.

A literature search was performed using Ovid Medline search and using key words "hyperparathyroidism", "daycase", "parathyroid", "minimal access surgery" and "minimally invasive parathyroidectomy" to identify papers published between 2005 and 2018 to study their average hospital stay, percentage of day-case procedures, cure rate and complications. Papers that had a study size of less than 50 patients in the MIP group were not included in Table I.

(Table I)

The cure rate in this series was 95% and in keeping with published literature. As mentioned previously, the analysis of our data showed an increasing trend of performing O-MIP as day-case. This most likely reflects the learning curve in the department. In the last four years, 98% of cases were done as day-case and there have been no significant complications. Other studies (see Table I) have shown that in 49-95% of the time, MIP can be done as a day-case with low complication rate and support the hypothesis that day-case MIP can be safe.

There are several identified factors in our study that have contributed to the safety and efficacy of day-case OMIP. These include:

1) Having an endocrinologist to confirm the diagnosis of pHPT and then referring the patient on to the surgical team
2) All pre-operative localisation scans were performed and reported by a dedicated radiologist
3) Only single adenomas were booked for a day-case procedure
4) Efficient pre-operative assessments were done by the pre-assessment unit to ensure patients were medically optimised for day-case procedures
5) All O-MIP procedures were performed/supervised by one experienced senior surgeon
6) The day surgery unit was well aware of the post-operative protocol
7) Arrangements for intra operative PTH & frozen section with a quick (20 minutes) turn around

Conclusion

O-MIP is a safe and effective procedure in the treatment of pHPT due to solitary adenoma. Accurate localisation is the key to successful O-MIP. With appropriate patient selection, experienced multidisciplinary team (including endocrinologists, radiologist and surgical team), and support systems in place for patients, O-MIP can be performed safely as a day-case procedure.

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Abstracts: ENT Masterclass Trainees' Gold Medal 2018

Insulin Like Growth Factor Receptor 1 (IGF-1R) and Radiotherapy Resistance in Laryngeal Squamous Cell Cancer (LSCC)

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Introduction
Salvage surgery is the only option for radiotherapy failure LSCC, but is associated with high morbidity. There is a need to identify biomarkers of radioresistance, to inform treatment decisions. Epidermal growth factor receptor (EGFR) associates with radioresistance in head and neck cancer (HNSCC), and type 1insulin-like growth factor receptor (IGF-1R) correlates with radioresistance in other tumour types. We recently reported that IGF-1R associates with advanced T-stage, HPV negativity and adverse survival in HNSCC. Here, we evaluated IGF-1R and EGFR in predicting radiotherapy failure in LSCC.

Methods
We scored membrane, cytoplasmic and total (membrane plus cytoplasmic) EGFR and IGF-1R using immunohistochemistry on biopsies and salvage laryngectomies from 63 LSCC patients, including 41 treated with radiotherapy (23 long-term remission, 18 local recurrences) and 22 with primary laryngectomy.

Results
IGF-1R scores were higher in the biopsies of the radiotherapy failure group, with scores in the membrane of 3.07 vs 1.0 (p=0.004), cytoplasm 3.36 vs 2.17 (p=0.18) and total IGF-1R 6.43 vs 3.17 (p=0.01) compared with those achieving long-term remission. IGF-1R expression was positively associated with tumour size and EGFR expression and was unchanged following radiotherapy. EGFR scores did not correlate with radiotherapy outcomes. Patients undergoing primary laryngectomy had higher T and N stage (p<0.05) and higher tumour IGF-1R (8.3 vs. 3.17, p=0.02) than those achieving long-term postradiotherapy remission.

Conclusions
These results suggest that IGF-1R associates with radiotherapy resistance in LSCC. Treatments accounting for IGF-1R status, or molecular therapies targeting this receptor, may have merit in patients whose tumours overexpress IGF-1R.

How do head and neck cancer cells regulate macrophage response in *vitro*?

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Background
Head and neck cancer is the sixth most common malignancy worldwide with squamous cell carcinomas comprising the overwhelming majority. Cancer survival and proliferation is dependent on the ability of recruiting monocytes and converting them into tumour promoting Tumour Associated Macrophages. The aim of this study was to set up an in vitro human head & neck cancer model to study macrophage behaviour in the tumour microenvironment and to identify the genes specifically expressed for an immune suppressing role.

Methods
2D and 3D models using human macrophage cell line (THP-1) with head & neck squamous carcinoma cell lines (HNSCC) and their conditional medium were used. Cytokine production and gene expression were examined by ELISA and real-time quantitative PCR, respectively. Cell aggregation and migration was assessed using time-lapse microscopy.

Results
1) TNFα was transiently produced at 24 hours co-culture and reduced within 48 hours, partially due to TNFα use by HNSCC cells. 2) Macrophage adherence and migration toward HNSCC occurred immediately after co-culture, but not observed in controls. 3) IL-35 introduction into the HNSCC and THP-1 co-culture caused a significant reduction in TNFα production by THP-1 cells. 4) Co-culture of THP-1 with HNSCC increased gene transcription of IL-35 subunits in addition to CD^{206} and IL^{4}-R.

Conclusions
HNSCC produce soluble and membrane bound proteins that induce TNFα production in macrophages and convert macrophages into a tolerogenic Tumour Associated Macrophage phenotype. Antagonism of this tolerogenic pathway could be a novel therapeutic target in the treatment of HNSCC.

Assessment of labyrinthine function in patients with chronic middle ear disease using combined VHIT and BC-VEMP testing

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Objective
To assess vestibular function in patients with confirmed middle ear disease. To evaluate the additional time needed to incorporate vestibular testing into routine pre-operative clinical assessment.

Setting
Ear Nose and Throat Department from a Tertiary Referral Centre.

Patients
Twenty patients awaiting surgery for chronic middle ear pathology were recruited with the following aetiological breakdown cholesteatoma (11), otosclerosis (2), chronic discharging ear (4), perforation (2) and meatal stenosis (1).

Interventions
All patients under went underwent bone-conduction ocular and cervical vestibular evoked myogenic potentials (BC-VEMPs) in both ears. Video head impulse testing (vHIT) was conducted for the lateral, anterior and posterior canals for both ears also. The time taken to complete the tests was recorded separately.

Results
The average time taken to complete the ocular and cervical VEMP tests was 5.7 ± 2.0 and 9.1. ± 1.9 minutes respectively for both ears. The time needed for vHIT testing of all six semicircular canals was 6.8 ± 2.0. Using a combination of vHIT and VEMP, abnormal findings were found in 16 of the 40 ears tested (40%).

Conclusions
This study has confirmed that a combination of vHIT and VEMP testing can provide a practical method of assessing the vestibular apparatus of patients with chronic middle ear pathology. With an average test time of less than 20 minutes and a pick-up rate of 40%, this new test paradigm provides an effective method of evaluating this ordinarily difficult-to-test patient cohort.

A Systematic Review of Tyrosine Kinase Inhibitors and Thyroid Neoplasia

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All authors have given permission for submission.

Introduction

Of all endocrine tumours thyroid cancer is the commonest; representing approximately 1% of all malignancies. Annual incidence data for thyroid cancer in the UK from 2008 shows 5.1 per 100,000 women and 1.9 per 100,000 men are affected. The incidence of thyroid cancer is increasing globally, mostly due to an increase in papillary thyroid carcinoma (PTC).

The mainstay of treatment for thyroid cancer is surgical resection, and patients with more advanced disease will also receive radioiodine (RAI) ablation; however, 5–15% of patients are refractory to such treatment. The prognosis for these resistant patients is incredibly poor. For these patients alternative adjuvant treatments such as tyrosine kinase inhibitors (TKI) are now available but not very commonly used.

This systematic review examined the current evidence for the efficacy of the TKI that have been used to treat advanced thyroid cancer concentrating on the four FDA approved drugs for the treatment of advanced or radioiodine refractory thyroid cancer.

Design and Results

Medline, Embase and Google Scholar were searched with the Key search terms of thyroid cancer, thyroid neoplasia and tyrosine kinase inhibitor. Individual TKI were also searched on the above databases.

35 phase II and phase III trials were identified. Most were double blind randomised. The resulting clinical trials were then reviewed with respect to tumour response rate and side effect profile.

Conclusions

There is evidence of efficacy however the side effect profile is concerning and as such patient choice remains a key factor

Grommets or hearing aids for otitis media with effusion in children?

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Introduction

Otitis media with effusion (OME) is common in childhood and in children with persistent OME, grommets or hearing aids are recommended. We aimed to compare the outcome of children undergoing either treatment in 2015 and 2017.

Methods

Retrospective notes review of all children who underwent grommet insertion between April to July 2015 and 2017. We also assessed simultaneous hearing aid referral pathway of those that preferred not to have grommets inserted.

Results

In 2015, there was an average of 70 days' waiting time from referral to hearing aid fitting whilst the average waiting time for grommet insertion was 36.1 days. In 2017, the waiting time for grommet insertion increased to 52.4 days. The average pathway duration from referral to discharge for hearing aids was 19 months. We found both in 2015 and 2017 a significant number of children who were referred for hearing aids required multiple pre-fit appointments due to fluctuating hearing loss. A total of 61 children underwent grommet insertion in 2015 compared with 47 in 2017. Complications from grommet insertion were low for both years studied.

Conclusion

This project allowed us to personalise treatment of children with OME taking into account not only urgency of the intervention but also the parents' reliability for follow up. Challenges of using hearing aids for children with fluctuating hearing were also highlighted. Grommet insertion may be a more cost effective treatment for OME compared with hearing aids.

Giant parathyroid adenomas of the neck – A minimally invasive approach

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Introduction

Sporadic primary hyperparathyroidism, characterised by hypercalcaemia and raised parathyroid hormone levels, is due to a solitary parathyroid adenoma in 80%–85% of cases. Presenting symptoms including fatigue, polydipsia, polyuria, bone pain, constipation, depression, and associated conditions, including nephrolithiasis and haematuria. A normal parathyroid gland weighs 38 - 59mg. A "giant parathyroid adenoma" is defined as a pathological weight greater than or equal to 3.5g. We present a case series of 17 giant adenomas and discuss the challenges of a minimally invasive surgical approach in these technically more difficult cases.

Methods

A case note review of 17 giant adenomas operated on at a single institution between 2006 and 2017 by the senior author was performed. There were 8 males and 9 females, with a median age of 62.1 years. Of note, patients had dual modality imaging consisting of an ultrasound and sestamibi scan to determine the presence and position of parathyroid adenomas. They are then reviewed in a parathyroid ENT clinic and are booked for day-case minimally invasive parathyroidectomy. Data was collected on patient demographics, symptoms, biochemistry, ultrasound and sestamibi results, operation outcomes, complications and histopathology.

Results

The location of the glands in the pre-operative imaging was 100% concordant with the intra- operative location. The weight of the adenomas ranged from 3.5g – 20g with a mean of 6.36g. Histology confirmed all the glands to be benign. All patients had a complication-free postoperative period.

Discussion

Our case series of 17 demonstrates that adenomatous glands up to 20g in weight can be excised using a minimal invasive open approach. The success of the minimal invasive approach for such large glands we believe is due to pre-operative work carried out by a dedicated multidisciplinary parathyroid team.

Brain waves and electrode interactions - objective assessment of auditory processing in cochlear implant users

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Background
Despite the great success of cochlear implant (CI) technology, there is still substantial unexplained variability in hearing outcomes. Much of this variability may be related to differences at the electrode-neural interface and subsequent auditory processing. The aim of this study was to determine whether EEG can be used to objectively assess auditory processing in CI users.

Methods
Fifteen adult CI users were recruited to the study. Auditory processing was assessed by measuring ability to discriminate neighbouring CI electrodes using two methods. The objective method utilized EEG to measure the 'auditory change complex' (ACC) which is cortical potential in response to a change in an ongoing stimulus. The behavioural method involved a simple discrimination task. Electrode discrimination and speech perception were tested at multiple time points during the first 12 months after switch-on.

Results
There was a strong relationship between behavioural and objective measures of electrode discrimination. The amplitude of the ACC increased significantly with CI experience, providing evidence for remarkable auditory plasticity, even in pre-lingually deafened adults. Interestingly, in several cases, objective discrimination developed prior to behavioural discrimination, indicating that stimuli can be encoded in the auditory pathway but not accurately perceived. In addition, a significant relationship between speech perception and electrode discrimination was found.

Conclusion
The ACC is a valid measure of electrode discrimination in CI users and may provide information over and above behavioural testing. We suggest that such objective measurements could be used to guide management of CI users.