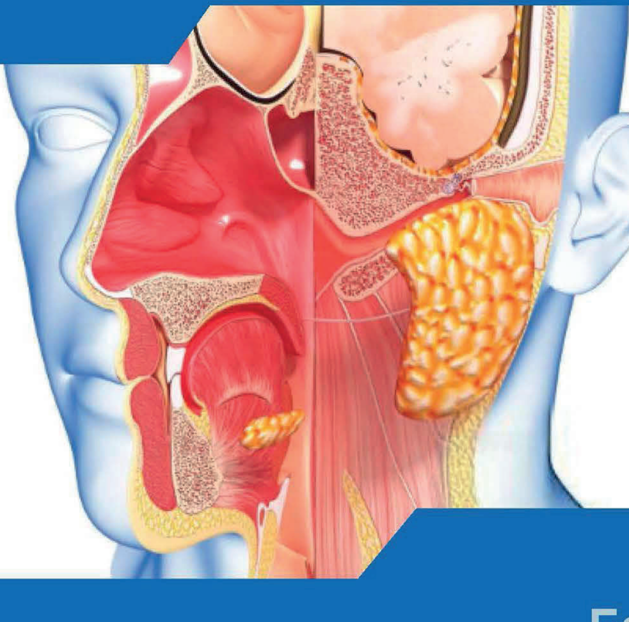
Bailey & Love's
Essential Operations in
Oral and Maxillofacial Surgery



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Foreword

By P. Ronan O'Connell

It is a great pleasure to introduce the first edition of *Bailey & Love's Essential Operations in Oral and Maxillofacial Surgery* and to congratulate editors Professor Peter Brennan, Mr Rabindra Singh and Professor Kaveh Shakib, their contributing authors and our B&L publishers on this excellent book.

Bailey & Love's Short Practice of Surgery, first published in 1932, has been venerated by generations of medical students and surgeons as a repository of the core knowledge needed for safe surgical practice. However, the editors understand that in the modern era, a parent textbook can only cover knowledge essential for early surgical training and recognise the need for a compendium of texts to take B&L readership to the next level of speciality knowledge.

Bailey & Love's Essential Operations in Oral and Maxillofacial Surgery is the first in a planned compendium of operative texts designed to support trainees in higher surgical and sub-specialty training. The current text remains true to the heritage and traditions of the parent textbook. The most up-to-date content in Oral and Maxillofacial Surgery is presented in a familiar format and style. The text, written by a series of internationally renowned authors, is clear and concise throughout. Each chapter is richly illustrated with operative photographs and accompanying line diagrams where needed.

A particular feature of each chapter is a section on 'Top Tips and Hazards' gleaned from years of expert practice. Such pearls of wisdom are a valuable addition to the text in keeping with the great traditions of Hamilton Bailey and McNeal Love.

I am sure readers will enjoy *Bailey & Love's Essential Operations in Oral and Maxillofacial Surgery* and trust that it will be a useful adjunct to their study and clinical practice.

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Editor in Chief, *Bailey & Love's Short Practice of Surgery*

Foreword

By Mike McKirdy

I am delighted to introduce this new first edition of *Bailey & Love's Essential Operations in Oral and Maxillofacial Surgery*. The original *Bailey & Love's Short Practice of Surgery* (now on its 28th Edition), has been used by generations of surgeons around the world. The addition of a new series of surgical sub-speciality operative textbooks by the publishers, and with the same ethos as Bailey and Love's itself, has been long awaited.

Bailey & Love's Essential Operations in Oral and Maxillofacial Surgery (OMFS) is a collection of comprehensive and contemporary practical resources designed to provide students, trainees, and specialist surgeons with a deep understanding of the principles, techniques, and innovations that define this specialised branch of surgery. It should be of interest to any surgeon who operates in the head and neck area including OMFS, Ear, Nose and Throat, Plastic, Reconstructive, and General Surgery.

This practical textbook has been meticulously compiled by a team of well-respected senior editors from the United Kingdom and is beautifully illustrated with operative images, supplemented by easy-to-follow diagrams as appropriate. It provides a step-by-step approach for the different operations across the whole remit of OMFS, and most chapters have references for further reading.

The editors have brought together respected experts from around the world for all the OMFS sub-specialties. The book also includes innovative chapters on human factors and improving safety in the operating theatre, medico-legal aspects of OMFS practice, head and neck imaging and the latest developments in tissue engineering.

There is no currently up-to-date textbook of operative OMFS available to rival this new title. Therefore, it should be the first point of reference for both trainees and established surgeons who have an interest in this rapidly expanding and fascinating specialty.

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Preface

Oral and maxillofacial surgery (OMFS) continues to advance at a great pace, which is testament to the skills that the specialty brings to benefit patient care. As with any surgical discipline, it is important that trainees grasp the basic principles of operative surgical practice before developing skills and competence in the various OMFS procedures. To prepare for these varied and often complex procedures, prior knowledge and understanding is important, and it enhances both performance and enjoyment in the operating theatre.

In this new book, developed from the renowned Bailey & Love series, we have aimed to cover the essential surgical techniques across the remit of the specialty and have enlisted the help of respected colleagues and trainers from around the world.

We believe that prior to performing any operative surgery, colleagues should understand human factors and how to minimise error in the operating theatre, so have included a chapter on this important subject at the beginning of this book. Following consideration of other relevant broader areas for safe surgical practice, the book has 10 further sections, taking readers through all the major OMFS sub-specialties. While we respect that some colleagues may not specialise in cleft, skull base, aesthetic or thyroid surgery, these have been included for completeness. To maintain consistency throughout, each chapter has been written and formatted in a similar manner, with (where relevant), essential surgical anatomy, operative steps, top tips and recommended further reading. Chapters have been illustrated with both operative images and/or drawings as necessary to aid understanding. The book concludes with a section on advances in OMFS including robotic surgery, interventional radiology and tissue engineering.

For a new project of this size, we respect that there may be areas that we have omitted or not covered in as much depth, given the publishing constraints. We would be delighted to hear from colleagues with suggestions for additional content or material that they would like to be included in any future editions.

We acknowledge that this new book title had its origins from *Operative Oral and Maxillofacial Surgery* edited by John Langdon, Mohan Patel, Robert Ord and Peter Brennan. We take this opportunity to thank John, Mo and Bob for their contribution over many years. We are also grateful to contributors from that book who have written chapters here, and to those who kindly allowed their chapters to be updated and revised for this new title.

Finally, we hope that this new book will not only help colleagues in their understanding of technical surgery in our complex and varied discipline, but that it will also benefit patient safety.

Primum non nocere

Peter A. Brennan
Rabindra P. Singh
Kaveh Shakib

We dedicate this edition to our trainees – past, present and future.

Acknowledgements

Authors from *Operative Oral and Maxillofacial Surgery*, Third Edition edited by John Langdon, Mohan Patel, Robert Ord and Peter Brennan.

In this day and age, it is impossible to produce a book like this without the contribution of numerous individuals. Although it would be impractical to mention all those who have played a part in producing *Bailey & Love's Essential Operations in Oral and Maxillofacial Surgery*, we would be remiss not to mention those whose chapters from *Operative Oral and Maxillofacial Surgery*, Third Edition informed the basis of many new chapters.

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PART 1 | Broader considerations in operative maxillofacial surgery

Chapter 1 Human Factors to Improve Patient Safety and Teamworking

Peter A. Brennan, Rachel Oeppen, Steve Jarvis

INTRODUCTION

Error is a part of being human and can almost be considered as 'normal'. We make, on average, five to seven mistakes every day. When we go to work and particularly to the operating theatre, we do not deliberately intend to cause medical error, but sadly some sort of error occurs with 1 in 20 hospital admissions, and of these another 1 in 20 (so 1 in 400) is serious, often resulting in patient harm.

In this chapter, human factors and their application, including various methods to help reduce error and promote better team working and morale, will be discussed. Factors that affect individual performance including hunger, hydration, emotional state and tiredness will be considered. Effective communication, situational awareness (SA) and ways to improve team working will then be discussed. By making changes to practice, patient safety can be improved and working experiences enhanced.

WHAT ARE HUMAN FACTORS?

There are many definitions of this term, but a simple one to remember is how we interact with each other (in teams), the systems in which we work, our variability and the factors that affect our performance and those of team members. Human factors (HF) application in healthcare can lead to improved patient safety, better team working and improved staff morale.

We all make mistakes, with an average of five to seven simple errors affecting each of us every day. We accept annoying errors such as forgetting a wallet or mobile phone as an inevitable part of day-to-day life, but often fail to appreciate that highly consequential errors in our work (causing patient harm and mortality) happen for the very same reasons. Just as we cannot prevent all day-to-day errors, we can never completely eliminate error in our professional work. Hence, the term 'never event', which includes wrong site surgery, retained instruments and swabs and incorrect nasogastric tube placement, is something of a misnomer.

The Roman philosopher Cicero (106–43 BC) wrote, "anyone is liable to err (make a mistake), but only a fool persists in error". Learning from mistakes and sharing lessons widely with others is one of the most important elements to improving patient safety across healthcare.

ERROR IN HEALTHCARE

The interplay of human error and HF in clinical incidents (including the many factors that have their origins in the hospitals and organisations where we work) is becoming more widely understood. It is often more than one issue (or layer) that leads to error, and this is readily represented by the well-known Swiss cheese model (***Figure 1.1***). Often factors are multifactorial and take place simultaneously – recognising this fact is the first step to understanding HF application in surgery. These multifactorial issues include ones that affect us as individuals such as tiredness, repetition, stress, the effects of distraction and multitasking. Other factors can occur as part of team working and these include poor communication or leadership, loss of SA and steep (or flat) authority gradients. The introduction of the World Health Organization (WHO) surgical checklist has improved attitudes toward pre-surgery briefing and patient safety and the benefits of recognising and applying these HF principles in surgery is well known.

One in 20 hospital admissions results in some form of error, and of these 1 in 20 (so 1 in 400 admissions) is serious. The operating theatre is known to be one of the most dangerous places in the hospital as a result of high patient turnover, site-specific treatments, many heterogeneous surgical procedures, staff limitations and unfamiliar teams.

What are the different types of error and failure?

The Human Factors Analysis and Classification System (HFACS) categorises failure across four broad domains in line with Reason's Swiss cheese theory (***Figure 1.1***). These are (1) organisational influences; (2) unsafe supervision; (3) preconditions to unsafe acts; (4) unsafe acts. The theory is that in ideal environments, single errors (unsafe acts) rarely happen, and even when they do, they are mitigated or captured such that no harm results from them. However, occasionally, a combination of problems at each level interacts or accumulates and a

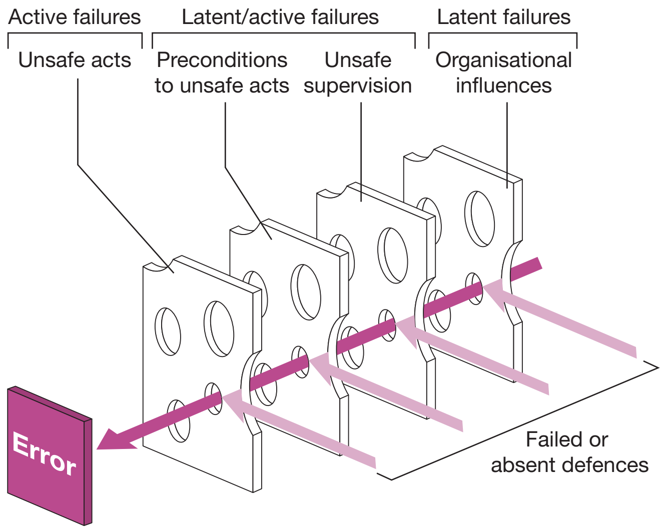


Figure 1.1 The Swiss cheese model of human error. Each 'slice of the cheese' can act as a barrier to prevent error or can facilitate occurrence of an error.

'perfect storm' of conditions results in which an error or accident occurs.

In the cheese metaphor, such a combination is represented by a hole in each cheese slice aligning to allow the accident through (*Figure 1.1*). This would be a result of a mix of organisational issues (such as demoralised workforce), poor supervision (such as unsupported staff), error-promoting conditions (such as poor lighting or poor equipment design) and, once the error occurs, no barriers to stop it causing damage (such as no alerting system when the wrong switch is selected).

Following this theory, in preventing accidents caused by human error, it is important to look at all levels of the organisation rather than simply the individuals. Examples of failures in the clinical setting that can have their origin in the employing organisation include pressures of overbooked clinics or operating theatre sessions, meeting clinical and hospital targets and prolonged working hours without breaks. Medical error may therefore begin to develop well before the actual event itself (such as wrong site surgery) as a result of institutional failure.

WHAT HUMAN FACTORS SHOULD WE BE CONSIDERING FOR SURGERY?

Table 1.1 summarises some important HF that can contribute to and ultimately lead to surgical error as categorised by the HFACS. These include factors that affect us as individuals such as tiredness and fatigue, nutritional status, emotional states including anger and stress, multitasking and loss of SA. These will now be considered further.

Tiredness and fatigue

Both commercial and military aviation recognise how tiredness and fatigue can influence personal performance and increase the likelihood of accidents and as a result, there are rules in place for maximum work hours. Tiredness (a state that can only be reversed by sleep) and fatigue (more complex in its aetiology and can be the result of chronic tiredness, physical or mental exhaustion) are both found in surgical team members. Both can reduce complex cognitive tasks, decision making and SA as well as impairing our technical and physical performance. The value of taking regular short breaks, for example during a long and complex 8-hour operation, is not only beneficial for individuals and teams but may also prevent error from occurring. Most would not drive for 8 hours non-stop so why can it be deemed safe to do so for surgery? One useful fact to remember is that our cognitive function after being awake for 18 hours is comparable with being twice over the UK legal alcohol limit for driving. Increasingly, employers recognise that tired clinicians are much more likely to make a mistake, not to mention the effects on mood and general wellbeing. No one else knows how an individual feels, and if they have been operating throughout the night and are expected to work the following day, the few words "I don't feel safe" can be very powerful when discussing with managers or other colleagues.

TABLE 1.1 Simplified Human Factors Analysis and Classification System (HFACS) relevant to surgery. The different levels are analogous to the holes in the Swiss cheese model lining up to cause an error

Organisational influences within the hospital
Hospital targets and pressures to deliver results (either perceived or real)
Climate, process and resource management within the hospital
Communication, training and recognition by the senior management of human factors responsible for possible error
Unsafe supervision
Inadequate supervision of trainees or other healthcare staff
Failure of briefings/complacency with WHO checklist
Failure of the team to know what to do when things go wrong
Loss of situational awareness, especially if not recognised by the theatre team
Preconditions to unsafe acts
Fatigue, hunger and nutritional status
Emotional influences (anger, personal issues), running late
Tiredness, boredom, communication issues, remember HALT
Environmental factors: background noise, distractions, lighting, ambient temperature, humidity
Panic
Unsafe acts (less likely)
Unfamiliar with changes from what is seen as a ‘normal event’
Distracting and multitasking
Operating outside of one’s area of expertise, or following a long period of no operating (surgical currency)

Abbreviation: HALT, Hungry, Anxious/Angry, Late (or Lonely), Tired.

Hydration and nutritional status

Hydration, nutrition and individual recovery are often overlooked areas of HF but are crucial in the operating theatre to maintain performance. Even small deficits in total body water can have a significant impact on cognitive function, resulting in poorer decision making, causing sleepiness, headaches, impatience and apathy. For example, a 1–2 kg loss of body water from an individual of average build reduces cognitive function by 15–20%. This tends to happen slowly so that the individual is unaware of their deteriorating performance. Sufficient hydration is particularly important if personal protective equipment (PPE) is being worn, as this can increase the rate of perspiration and loss of body water. Water requirements are unique to individuals and, while a multitude of factors including body mass, ambient temperature, pregnancy and diet play a role, the minimal requirement is approximately 2 litres per day.

Good, balanced nutrition distributed over a sensible time period also helps to optimise personal performance and supports complex mental and physical tasks over a sustained period, for example, consumption of a well-balanced, small-portioned meal every 3–4 hours consisting of complex carbohydrates, protein and healthy fats. In contrast, large meals eaten over erratic time periods consisting of simple sugars or processed foods are more likely to produce fluctuating energy levels, which can have a detrimental effect on work. One only needs to consider athletes to realise how effective good nutrition can be at improving performance. Planned breaks during long operating lists, clinics and on-call periods also ensure enough opportunity can be afforded for all team members to recover.

Emotion and stress

Mental perspective and its impact on work performance needs to be recognised. Powerful emotions such as anger or upset can easily interfere with decision making, especially when trying to perform a task that requires intense concentration. The operating theatre can itself be a stressful environment for the surgical team – many will have heard colleagues raise their voices, which can be a result of stress or other factors aligning. In such situations, error is far more likely, not to mention the potential effect of loss of civility on the wider team, which can lead to respect being lost, among other negative effects.

Pausing during an operation (if it is safe to so do) to address any underlying issues may reduce the likelihood of error. We recommend taking a short break, again if it is safe to do so. Bringing the above factors together,

Figure 1.2 HALT is a simple mnemonic to prompt us to stop, if safe to do so, when any of these factors arise. Each can raise the risk of error.

the easy-to-remember mnemonic HALT – Hungry, Anxious/Angry, Late (or Lonely), Tired – is a powerful reminder of the factors that can lead to surgical error, as well as recommending the value of stopping when one or more of these arise (*Figure 1.2*). Recognising the impact of stress and emotion not only helps reduce risk of error but also benefits surgical training and leads to more effective and happier team working, all of which ultimately improve overall patient management. 'Lonely' is included in the mnemonic as this introduces the idea of remembering the value of involving colleagues for complex cases or after a prolonged period of not operating (during COVID, for example). Dual surgeon operating can be very useful in this regard. Not only can this give surgeons confidence, but it can also improve patient outcomes.

Situational awareness

A simple definition of SA is being aware of what is going on around us (*Figure 1.3*). Awareness and appreciation of factors that raise the risk of medical error (summarised in *Table 1.2*) can be used to improve SA for both individuals and the whole team. However, it is important to note that SA is dynamic and can change quickly, and we must consider our ability (or not) to adapt to such changes. For example, a surgeon can become fixated on a task, develop tunnel vision and become blind to other factors that readily occur, thus losing wider SA. This can be exacerbated by confirmation bias in which the surgeon over-weighs cues or information that confirms the direction they are already following. This could include convincing themself of an anatomical structure or location when it is something quite different. Many errors have occurred as a result including, for example, cut bile ducts, ureters and important nerves.

Recognising the value of SA alongside a well-briefed team, all of whom feel safe and able to voice their concerns, provides the best environment in which to reduce the risk of medical error. In this way, team members are looking out for each other, thereby improving safety and working more effectively. By actively thinking ahead (having the best SA), errors can be avoided. Consider that the best drivers are those who anticipate problems early, thereby avoiding potentially hazardous situations. Similarly, thinking about and discussing with the team any potential 'what if?' scenarios before an operation commences can reduce the likelihood of a startle reaction, and ensure the team is best prepared.

The concept of PPP – Patient, Procedure, People (team) – has recently been introduced. This is a useful way of prompting oneself to regain wider SA when something does not seem quite right. In some circumstances, it may be the procedure that needs re-discussing first to help regain SA. In most instances, stepping back from the acute situation (if safe to do so) and discussing with the team is the best way to understand the problem and decide the best course of action. This tool has been adapted from the aviation mnemonic ANC – Aviate, Navigate, Communicate.

Figure 1.3 Situational awareness and being aware of what is going on around us is demonstrated clearly in this cockpit photo taken by one of the pilots of the UK Royal Air Force Aerobatic Team, The Red Arrows.

TABLE 1.2 Situations that might raise the chance of error in the operating theatre environment. Being aware of these can help improve situational awareness
High physical or mental workloads
Interruptions and distractions during key parts of an operation
Tasks requiring an 'out of normal' response and/or unanticipated new tasks
Multitasking
Changes in physical environment

TEAM BRIEF AND DEBRIEF, LOWERING AUTHORITY GRADIENTS AND ENHANCING COMMUNICATION

Patient care is rarely, if ever, performed in isolation from other team members. The introduction of the WHO checklist and team brief has resulted in significant improvements to patient safety in theatre. Enhancing team working, understanding, value and reduced hierarchy all contribute toward safer patient outcomes. The way in which a briefing is conducted is important. It should not be rushed and, from the outset, all team members should feel valued equally and empowered to speak up if they have any concerns, without fear of retribution. *Table 1.3* provides a summary of items that may be included in both briefing and debriefing sessions. The team brief should also stress the importance of looking out for each other to reduce the likelihood of losing SA and highlighting when factors such as tiredness and stress can be seen in others. During periods of intense concentration, surgeons can experience attentional tunnelling, and quickly lose track of time. Several hours can pass, and the reliance on others to keep an eye on the clock and suggest a short break perhaps after 3 hours is good practice.

Similarly, distraction of attention away from the primary task can be detrimental to performance at safety-critical times during the operation when full concentration is required. Any potential distractions should be discussed at the team brief and predictable distractions kept to a minimum. The sterile cockpit approach (where pilots focus only on flying below 10 000 ft with no distractions) is a valuable technique to apply in theatre. A simple distraction such as a telephone call asking for advice during a complex part of an operation significantly raises the risk of error. It is far better to either limit predictable distractions (including noise) during these times or stop and focus on one task at a time rather than trying to multitask.

At the end of the operating list, it is good practice to conduct a short debrief. This does not necessarily have to be formal, but it gives an opportunity to discuss what went well, and what could be improved for next time. The power of saying "Thank you" to the team cannot be overemphasised. Gaining feedback from other team members on our own performance is also valuable and builds practice and non-technical skills.

In aviation, the most junior airline pilot is actively encouraged to question the most senior captain without fear. Similarly, empowering all surgical team members including medical students, trainees, nurses and non-clinical staff to voice their concerns ensures a safe working environment for everyone. Of course, this has to be managed within reason by each individual, and the leader recognised as such, as they have the ultimate responsibility for the decisions made. A flat hierarchy is as dangerous as a steep one, as this can lead to situations such as no one knowing who is doing what, or the leader being unable to discharge their responsibilities. However, what is most important is to be clear that any team member can speak up if concerned without fear, and that their concern will be listened to.

TABLE 1.3 Items to consider during a team briefing. A debrief is a powerful way to develop and enhance team working for future operating sessions

A well-prepared team is advantageous in that every member knows their role and looks out for their colleagues. It can also help team members to feel valued.
Briefing
Introductions, open culture, "Please speak up if concerned"
Leadership, team working and decision making
Think about the 'what if?' scenarios that might occur during a procedure
Identify the major steps and who will be doing what
Ask "What am I expected to do if and when something goes wrong?"
Situational awareness – how to intervene when something does not seem right
Debriefing
Consider debriefing for learning
What went well?
What should we do differently next time?
What do you think about my performance today?
Saying "Thank you" to the team!

Effective communication between team members is an essential element to good team working and interaction. Regular use of open questions such as "What do you think we should do? What would you suggest here?" is a good tool to bring the team together. The use of pronouns (e.g. "Pass me it/that") should be avoided, especially at safety-critical times; instead, use of proper nouns (e.g. the name of a required instrument) will ensure clear instructions. Finally, 'repeat back' is a useful tool to confirm that a message has been heard and understood by the receiver. Just because a team member has said something, does not automatically mean that others have heard and understood the message or instruction.

In summary, HF application is essential to ensure both individuals and teams are best optimised to care for patients. Some elements are simply common sense, stopping for a short break regularly just as we would do while driving a long distance. However, it can be all too easy to leave common sense at the front door of the hospital when we come to work.

TABLE 3.3 (*Continued*) Imaging of maxillofacial malignancy

	2. Surveillance imaging: • Persistent primary/nodal disease post-chemoradiotherapy • Surveillance of primary tumour with high risk of recurrence
	3. In the setting of an unknown primary tumour ideally prior to panendoscopy and biopsy
	4. Rarely for assessment of primary or nodal disease for primary staging
Ultrasound	• There are advantages of ultrasound (relative to MRI/CT) for nodal assessment • Ultrasound uses additional criteria to detect smaller pathological nodes and may also be used to guide FNA • Utility is guided by local expertise • Particular scenarios in which ultrasound ± FNA may be required include indeterminate contralateral nodes in the N0 neck using CT/MRI

can be combined with fine needle aspiration (FNA) for cytology or core biopsy for histopathology, making it a highly specific diagnostic tool.

The choice of where to start scanning will depend on the clinical scenario. For example, for a patient with a lipoma of the posterior triangle, a detailed assessment of both sides of the neck is not required, whereas a patient with a squamous cell carcinoma (SCC) primary who is undergoing a staging scan of the neck needs a bilateral assessment of all the major lymph node territories in the neck.

The following indications will be considered:

- Lymph node assessment
- Salivary glands
- Imaging lumps and bumps
- Ultrasound-guided FNA and percutaneous core biopsy

Lymph nodes

Normal nodes have a well-defined ellipsoid shape, with an intermediate to low reflectivity homogeneous cortex and highly reflective central hilus. Overall length is irrelevant, with normal cervical nodes frequently measuring 3–4 cm in maximum longitudinal (L) dimension. However, short-axis (S) measurements should not normally exceed 10 mm. The more rounded a node, the more likely it is to contain metastatic disease (***Figure 3.2***).

Abnormal nodes display reduced reflectivity (i.e. tend to be hypo-echoic or 'black') with a tendency to lose the central echogenic hilus. Vascularity may increase and have a disordered pattern. Peripheral or subcapsular vessels are a particularly strong sign of malignancy.

Lymphomatous lymph nodes characteristically appear rounded, often retaining a central echogenic hilus, and possess a homogenous, hypo-echoic (pseudo-cystic) cortex. Colour flow imaging often reveals plethoric hilar vascularity. Identification of these characteristics should prompt the operator into carrying out a core biopsy or recommending excision biopsy depending on local preference to allow rapid diagnosis.

Salivary glands

The most common problems encountered include sialolithiasis, inflammatory conditions and tumours.

Sialolithiasis

Intraglandular calculi are easier to identify than ductal stones. Frank duct dilatation (***Figure 3.3a–d***) or sialectasis may be seen, and ultrasound will also demonstrate the complications of calculi, including abscess formation and sialocele.

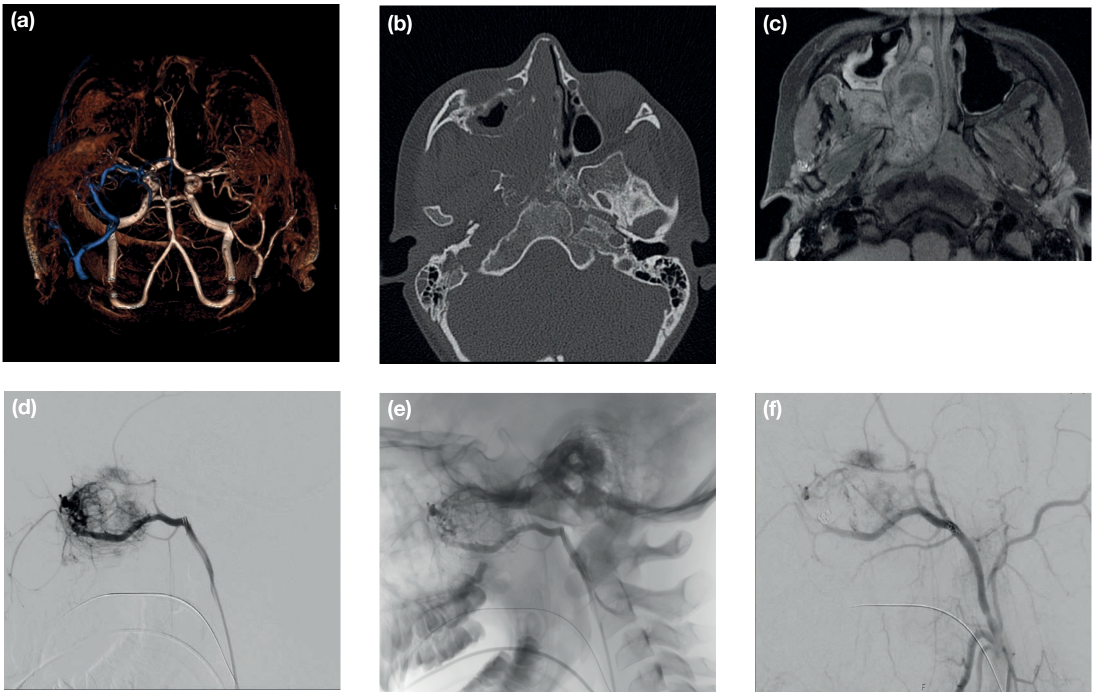
Ultrasound cannot definitively exclude calculi. If there is a strong clinical suggestion of salivary duct obstruction and ultrasound examination is negative, sialography will be required to exclude a stone/stricture (***Figure 3.4***).

Inflammation

Acute salivary gland inflammation occurs in response to suppurative sialadenitis and viral infection. Inflammation causes gland hypertrophy and hypo-echogenicity, that is, the salivary glands lose their normal bright echotexture. The association of Sjögren's disease with lymphoma needs to be recognised and if a hypo-echoic mass is seen within an affected salivary gland, lymphoma must be considered.

Tumours

Approximately 80% of salivary tumours are benign, 80% occurring within the parotid with 80% of these being pleomorphic adenoma. The vast majority of parotid tumours lie within the superficial portion of the gland, allowing easy assessment with ultrasound. However, in the case of large or deep masses, the deep extent of a lesion can be difficult to assess (necessitating CT or MRI). Ultrasound cannot always predict whether salivary gland lesions are benign or malignant (although irregularity, abnormal vascularity and the presence of enlarged or suspicious nodes aid accuracy) and is



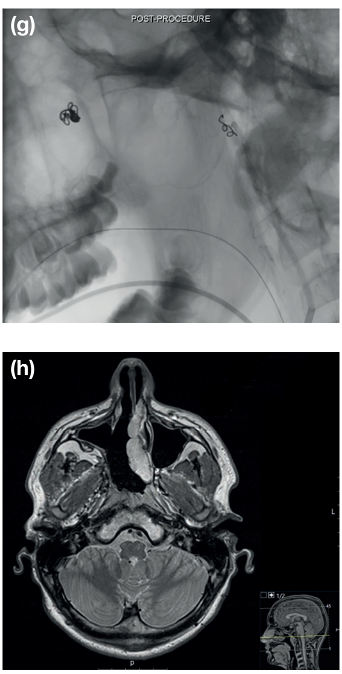


Figure 3.1 **(a)** 3D projection magnetic resonance imaging (MRI)-angio time of flight (TOF) in the arterial phase of a common/external carotid angiogram demonstrates a hypertrophic maxillary artery and vascular blush (in blue) secondary to a juvenile angiofibroma (JAF) in a 10-year-old boy. **(b)** Computed tomography (CT) shows widening of the right sphenopalatine foramen. **(c)** MRI axial T1WI fat saturated with contrast confirms large infiltrating JAF centred on the right sphenopalatine foramen and nasal cavity with classic punctate and serpentine flow voids. **(d)** Digital subtraction angiography (DSA) of same patient pre-embolisation showing arterial tumour parenchymal blush of the JAF after selective contrast injection into the right maxillary artery in lateral projection. **(e)** Unsubtracted image prior to embolisation. **(f)** DSA again in lateral projection post-embolisation prior to surgical intervention showing coils at level of arterial pedicle JAF and absence of arterial tumour parenchymal blush. **(g)** Unsubtracted image post-embolisation. **(h)** Post-treatment MRI T2WI without evidence of residual disease.

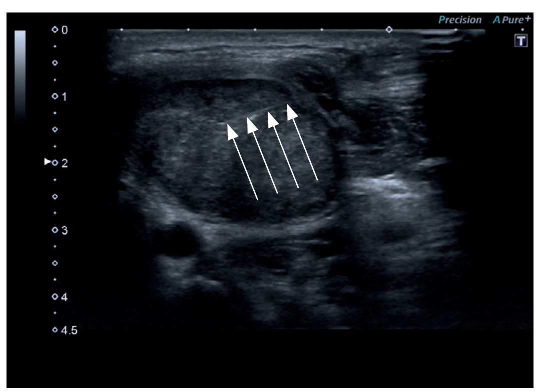


Figure 3.2 Node with greater than normal short/long ratio with needle for ultrasound-guided fine needle aspiration – a metastatic squamous cell carcinoma node.

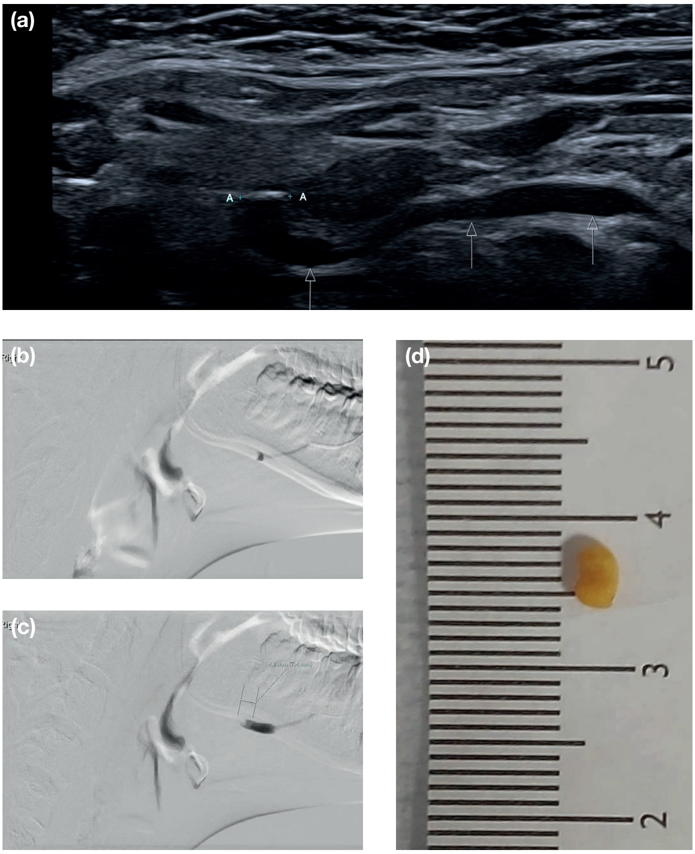


Figure 3.3 (a) Dilated main submandibular duct (arrows), typical of mobile ductal stone (marked between A's) on ultrasound. **(b, c)** Sialogram confirmed mobile stone on digital subtraction sialography. **(d)** 4-mm stone after ultrasound-guided basket retrieval.

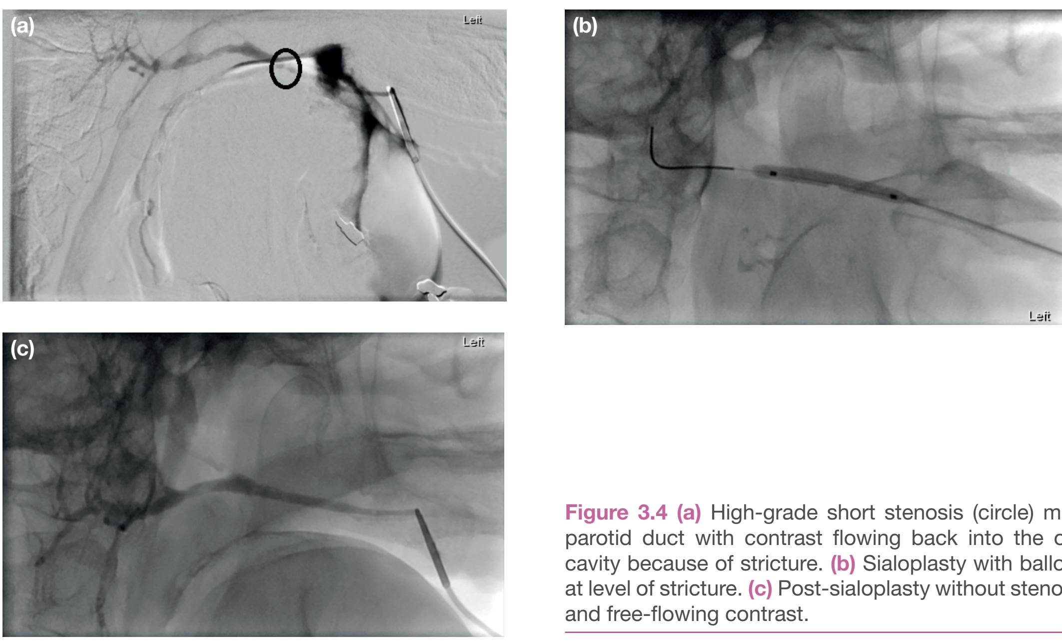


Figure 3.4 (a) High-grade short stenosis (circle) main parotid duct with contrast flowing back into the oral cavity because of stricture. **(b)** Sialoplasty with balloon at level of stricture. **(c)** Post-sialoplasty without stenosis and free-flowing contrast.

usually used in conjunction with fine-needle sampling. The smaller the salivary gland the more likely that any tumour detected will be malignant, that is, a tumour in the sublingual gland has a far higher likelihood of malignancy compared with a mass in the parotid gland.

Other malignant salivary gland tumours (mucoepidermoid, adenoid cystic and acinic cell carcinomas) occur more frequently in the sublingual and submandibular glands than in the parotid glands. Features suggestive of malignancy include poor definition with heterogeneous echotexture, disorganised colour flow and the presence of associated nodes. Using these criteria, malignancy can be predicted in around 80% of cases using ultrasound alone.

Lipomas

Lipomas are benign encapsulated subcutaneous lesions, which are frequently encountered in the neck. Typical sonographic features include hyper-echogenicity, linear internal echoes perpendicular to the ultrasound beam, compressibility and a lack of internal vascularity on colour flow or colour Doppler imaging. Intramuscular lipomas can mimic muscle and can be difficult to define with ultrasound.

Branchial cleft cyst

Most branchial cysts arise from the second branchial arch remnants, and present as a mass at the angle of the mandible, often following an infection. The typical location is abutting the posterior aspect of the submandibular gland, lying lateral to the carotid bifurcation and immediately anterior to the anterior border of the sternomastoid. On ultrasound, these lesions are typically cystic. It may be impossible to distinguish between a second branchial cleft cyst and a necrotic lymph node metastasis due to SCC.

Thyroglossal duct cyst

Thyroglossal duct cysts can arise at any position along the course of the thyroglossal duct remnant but the majority are related to the hyoid bone, with most occurring at the level of or inferior to the hyoid.

On ultrasound, thyroglossal duct cysts may appear cystic, heterogeneous or pseudo-solid due to varying content of debris, haemorrhage or infection. Classically, they are embedded in the strap muscles, often ‘splitting’ the strap muscles. Malignant degeneration of the epithelial lining occurs rarely and any solid component that appears to contain micro-calcification (i.e. suggestive of papillary carcinoma) should undergo sampling.

Thyroid gland

As the thyroid gland is situated in a superficial location in the anterior neck, it is readily imaged with ultrasound. A detailed description of thyroid ultrasound is beyond the scope of this text; however, thyroid disorders, including generalised gland enlargement and focal nodules, are relatively commonly encountered in clinical practice. In the one-stop clinic environment, thyroid nodules are likely to represent the second most common presenting mass, after lymph nodes. The increasing use of ultrasound means that incidental thyroid nodules are frequently detected in between 50% and 70% of females over the age of 50. Although thyroid nodules are very common, thyroid cancer is extremely rare.

Ultrasound-guided FNA and core biopsy

Ultrasound is a very useful adjunct in percutaneous sampling procedures, allowing direct visualisation of the needle and structures to be avoided.

For many conditions, for example SCC lymph node metastases, FNA will be the initial sampling technique. Core biopsy may be reserved as a second-line test when cytology is unable to provide the answer. However, where lymphoma is considered as a possible diagnosis, core biopsy undoubtedly has a superior role.

COMPUTED TOMOGRAPHY

Computed tomography (CT) is a modality with rapid image acquisition which is widely available. A CT scanner consists of an x-ray tube which generates and directs a fan of x-rays towards the body part of interest, and the attenuation of the x-rays by the patient’s tissues is detected. The process is repeated as the tube and detectors rotate and the patient is advanced through the scanner. The degree of x-ray absorption by each volume of tissue (voxel) is displayed as a pixel, which is allocated a number (Hounsfield unit). This information may be digitally manipulated to optimise visualisation of the tissues of interest (e.g. by changing the range of ‘numbers’ in the grey scale or ‘window width’ or by using algorithms to alter the ‘sharpness’ of the image). The same information may be used to provide multiplanar reformats or rendering of three-dimensional (3D) objects to facilitate visual assessment. Imaging of soft tissues generally requires the administration of iodinated contrast medium to demonstrate enhancing pathological tissues and delineate vascular structures from adjacent soft tissues such as lymph nodes. Artefact from metallic materials such as dental restoration may markedly degrade images of the face due to ‘beam-hardening artefact’; however, there are methods to reduce this, such as angling of the scan plane or the use of specific image reconstruction techniques. The availability of CT fluoroscopy and ‘in room’ CT controls/monitors has improved the safety and efficacy of CT-guided biopsies of deep facial and skull base lesions (***Figure 3.5***).

Multislice computed tomography (MSCT) acquires multiple slices per tube rotation. Current scanners

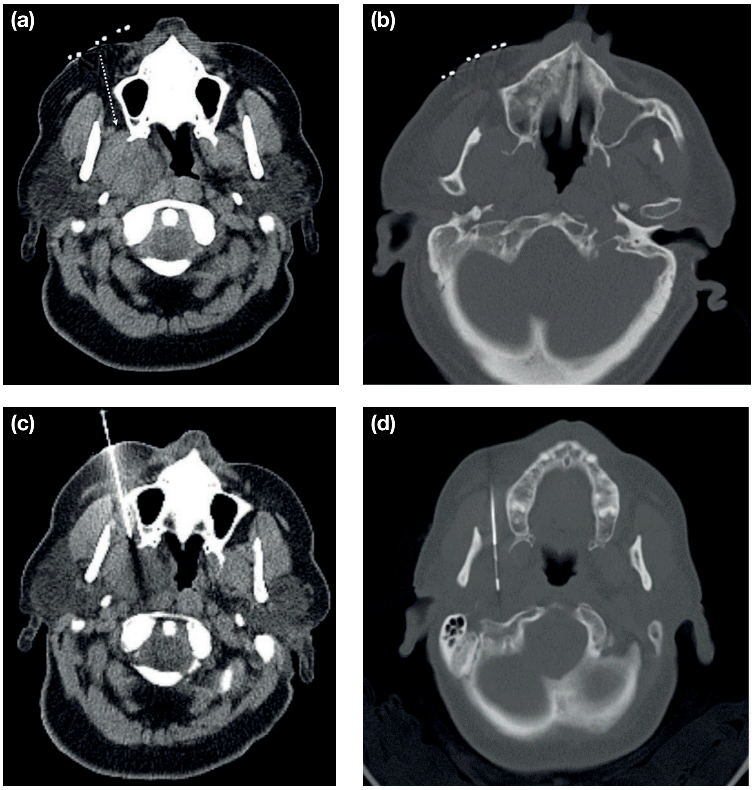


Figure 3.5 **(a)** Non-contrast soft tissue window axial computed tomography (CT) demonstrating skin markers overlying the right cheek with pathway through the buccal fat space (dashed arrow) to the right parapharyngeal tumour. **(b)** Bone window CT demonstrating skin markers, the right buccal space and remodelling of the right lateral pterygoid plate secondary to local mass effect from the right parapharyngeal tumour. **(c)** Coaxial needle passing through the right buccal fat space to the superficial margin of the right parapharyngeal tumour. **(d)** Core biopsy needle within the right parapharyngeal tumour with deployment of the cutting needle.

typically acquire 256 or 320 slices for some applications. MSCT has the potential to scan standard volumes with shorter acquisition times, so reducing movement artefact (e.g. due to swallowing) or requirement for sedation and optimising vascular opacification (e.g. for CT angiographic studies). MSCT also allows the scanning of larger volumes or the use of narrower section thickness (as low as 0.1–0.5 mm) so optimising the 3D dataset for post-processing and interactive 3D image-guided surgery.

The benefits of CT should always be weighed against the risks of ionising radiation exposure.

Cone beam computed tomography (CBCT) has developed as a technique that provides high-resolution 3D data at low-radiation doses (equivalent to 2–8 orthopantomograms (OPTs)). The equipment may resemble that of a conventional dental panoramic tomography unit (patient erect) or may mimic a conventional CT scanner (patient supine). A cylinder- or sphere-shaped volume of data is rapidly acquired with a single tube rotation. Some CBCT equipment is designed to simulate intraoral radiographs by imaging small volumes (e.g. two to three teeth) at high resolution, while other equipment is designed to image the whole maxillofacial region (e.g. 15 cm^3 spheres). The low tube currents utilised to reduce the radiation dose unfortunately preclude adequate imaging of soft tissue structures. Evidence-based guidelines for the use of CBCT in dental and maxillofacial radiology have been produced by the SEDENTEXCT project (www.sedentexct.eu/files/guidelines_final.pdf).

MAGNETIC RESONANCE IMAGING

Magnetic resonance imaging (MRI) does not require ionising radiation and is therefore recommended in cases where it would provide the same information as CT unless contraindicated. Advantages relative to CT are higher soft tissue resolution and less dental artefact but MRI scans take significantly longer, up to 30–45 minutes. Contraindications to the use of MRI include metallic foreign bodies including most cardiac pacemakers (see www.MRIsafety.com).

MRI delivers radiofrequency pulses within a high magnetic field, with the signals generated dependent on the behaviour of protons within the tissues. Signals can be resolved into two main components T1 and T2 (*Figure 3.6*). The benefits of MRI regarding soft tissue imaging become particularly apparent when imaging the meniscus of the TMJ (*Figure 3.7*). MRI contrast enhancement may be achieved with gadolinium-based agents. Patients requiring gadolinium are evaluated for the presence of severe renal insufficiency as there is a rare association with nephrogenic systemic

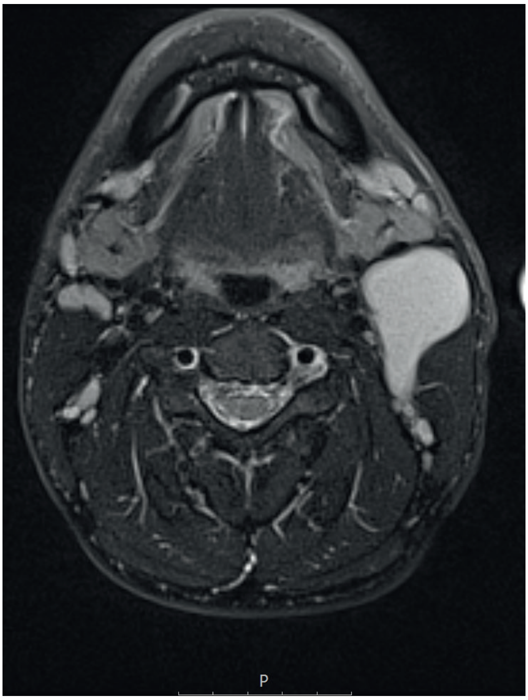


Figure 3.6 Axial T2-w fat-saturated magnetic resonance image shows a T2 hyperintense left second branchial cleft cyst.

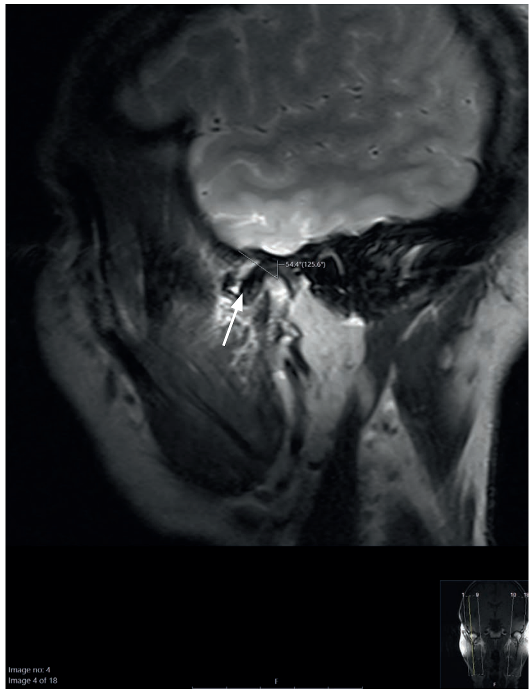


Figure 3.7 Sagittal T2 image of temporomandibular joint showing a small joint space effusion and partial anterior disc displacement (arrow) in open mouth position oblique parasagittal.

fibrosis (NSF). Pre- and post-gadolinium (contrast medium) T1-w sequences should be performed. T1-w sequences may also be combined with fat saturation post-gadolinium, such that increased signal due to enhancement is not masked by high T1 fat signal (see ***Figure 3.1c***). Gadolinium is used to characterise pathological lesions that exhibit variable signal and patterns of enhancement.

Typical imaging sequences for a study of the face and neck would include T1-w axial, T2-w axial, T1-w post-gadolinium axial, STIR coronal and T1 fat saturated post-gadolinium coronal images. Diffusion weighted imaging (DWI) is also a routine sequence in many centres, and has a developing role, being particularly useful in assessment of residual tumour following treatment with chemoradiotherapy.

POSITRON EMISSION TOMOGRAPHY AND OTHER RADIOISOTOPE IMAGING

PET differs from the previously mentioned anatomical techniques in that it provides functional imaging of metabolic activity. This has proved very useful in the setting of maxillofacial malignancy, with improved diagnostic accuracy relative to CT and MRI. Most PET imaging studies of the head and neck use the short-lived radiotracer 18-fluorodeoxyglucose (^{18}FDG), which allows examination of altered glucose metabolism as a marker of tumour activity. PET alone does not provide the same anatomical detail as CT or MRI. Functional and anatomical CT images (PET-CT), and MRI images (PET-MR) are therefore obtained on the same scanner.

PET must be interpreted with an awareness of the limitations in detecting small volume (particularly <3–4 mm) disease, including superficial mucosal lesions, lymph node micro-metastases and necrotic lymph nodes. Some tumours (such as salivary gland tumours) are not ^{18}FDG avid. Some centres use an objective measure of FDG uptake (SUV) to increase diagnostic specificity for malignant lesions. There are also pitfalls due to false-positive findings resulting from normal tracer distribution (e.g. salivary and thyroid gland, muscle activity and Waldeyer's ring) and inflammatory tissue (e.g. lymph nodes, early stages post-tumour treatment and healing bone).

ACKNOWLEDGEMENTS

We acknowledge the contributions of Roma Dave, Portsmouth Hospitals NHS Trust, and Dr Rhodri Evans.

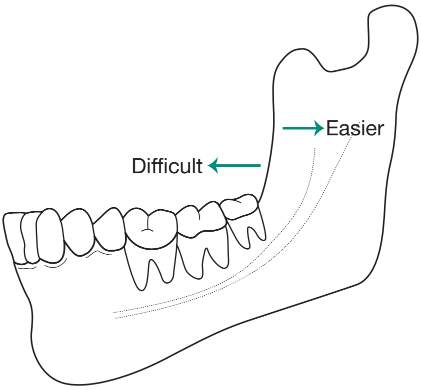


Figure 5.5 Position of the ascending ramus in relation to wisdom tooth.

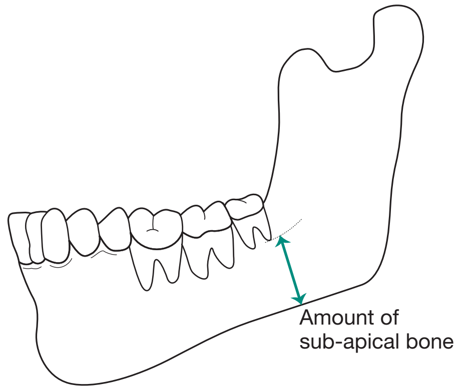


Figure 5.6 Assessing the amount of sub-apical bone.

with bleeding from the vessel and the possibility of sensory disturbance to buccal mucosa.

Height of the basal bone

A reduced amount of sub-apical bone below the apex of the wisdom teeth (***Figure 5.6***) is a risk for sustaining a mandible fracture during or immediately after removal of the impacted tooth.

SURGICAL REMOVAL

Removal of fractured molars: Upper and lower

If a tooth crown is fractured, the clinician requires access to remove the remaining tooth substance. Raising a flap is often necessary to visualise the remaining tooth and to allow necessary bone and root removal.

General principles for raising a flap

Prior to raising a flap, there are several important factors to consider. The flap design should ensure vascular supply to the entire length of the flap, protect adjacent anatomical structures, such as mental nerve, and allow the flap to rest on underlying bone to prevent soft tissue collapse. An ideal flap:

- Has a wide base and avoids transection of the gingival papilla
- Includes mucosa, submucosa and periosteum as a single layer
- Has adequate direct visual access to avoid unnecessary tension on the flap margins, which may lead to iatrogenic tear
- Allows for tension-free closure to prevent wound dehiscence postoperatively

Raising the flap

To raise a good full-thickness mucoperiosteal flap, it is important to incise down to the underlying surface of the bone. Care must be taken to avoid any slippage of the blade when met with underlying uneven bone. An intact full-thickness mucoperiosteal unit is vital for good bone healing, prevention of soft tissue collapse and avoidance of bleeding from the mucosal tear. To facilitate raising the flap as a single unit, a good periosteal elevator should be used, such as a Molt Elevator No 9, Buser Spear Head Elevator or a Prichard Elevator.

To prevent blunting of the interdental papilla, the incision must include the whole of the inter-dental papilla. Also, releasing incisions must avoid all the vital structures, particularly the mental and long buccal neurovascular bundles. Releasing incisions should not be made on the palatal or lingual aspects.

Flap designs for non-third molar teeth

Figure 5.7 illustrates three flap designs. The choice of which to use is at the clinician's discretion. A three-sided flap may allow a relatively inexperienced surgeon a wide access in which to perform the surgery. A two-sided flap may be preferred by an intermediate-level user, while experienced surgeons may prefer flapless minimal periosteal release with which to divide the roots and elevate them.

Bone removal

Bone removal is undertaken using a rose head bur with a high-speed electrical handpiece of minimum 35 000–40 000 rpm, with a saline coolant. There are two important reasons for performing bone removal:

- To expose the root and gain further hold on the tooth substance to facilitate extraction
- To remove inflexible cortical bone. With increasing age, the cortical bone becomes rigid and resistant to any elevation of the roots, therefore removal of the cortical bone is required. This process includes creation of a gutter by initially removing non-bleeding cortical bone around the roots, and then bleeding bone which confirms exposure of

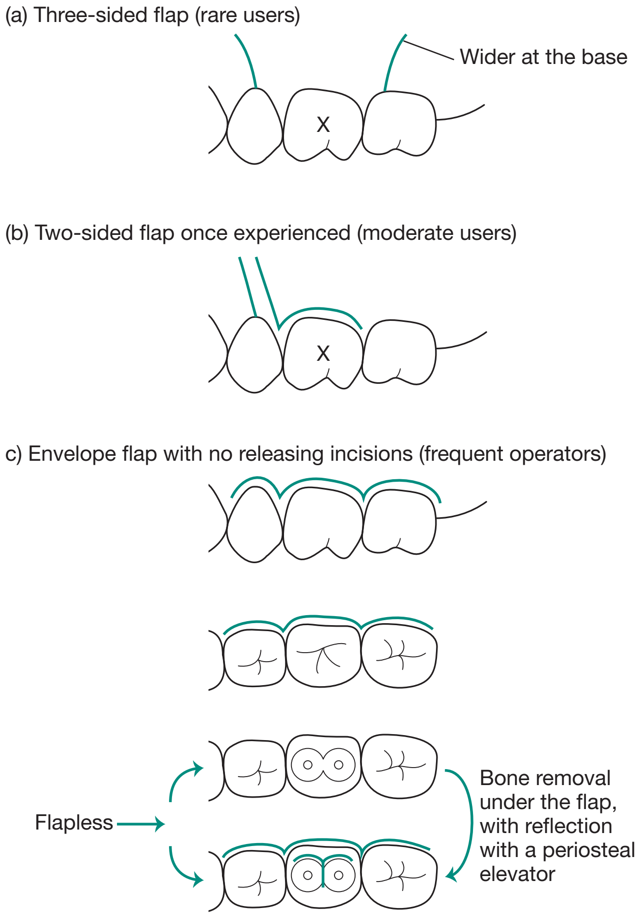


Figure 5.7 Flap designs for non-third molar teeth. **(a)** Three-sided flap for beginners, enables visualisation of the entire buccal bone to root relationship. **(b)** Two-sided flap. **(c)** Flapless/envelope flap without a releasing incision. Bone removal done around the roots to create a narrow gutter to mobilise the roots. x indicates planned extraction.

the underlying softer medullary bone (see ***Figure 5.16***). Softer medullary bone allows for easy root elevation

Lower molar surgical extraction

Figure 5.8 provides a diagrammatic representation of lower molar surgical extraction.

Upper molar extraction

Figure 5.9 illustrates upper molar extraction. An upper molar with three roots is divided into three sections: mesio- and disto-buccal roots and palatal root. Once divided, a luxator is inserted to individually elevate the root.

Suturing

A figure-of-8 suture is placed on the socket to assist with haemostasis (***Figure 5.9e***). The needle is passed through the mesio-buccal papilla to diagonally disto-palatal papilla, then re-entered to mesio-palatal papilla and then diagonally to disto-buccal. A knot is tied on the buccal aspect.

When to leave the roots behind

A root tip of <2–4 mm with no evidence of surrounding periapical pathology can usually be left behind. At times it may be difficult to visualise the root remnant and there may be a danger of displacing the root remnant into adjacent anatomical space such as maxillary sinus. In such circumstances, a decision may be required on whether to leave the root *in situ*. Occasionally, brisk bleeding or patient's ill health may support leaving the root tip and arranging any further removal as a second stage if indicated.

Maxillary tuberosity fracture

The incidence of maxillary tuberosity fracture while removing the last standing upper molars is around 0.6%. This section discusses prevention and management of this complication.

Prevention. Clinical: Surgical access depends on palatal or buccal inclination of the tooth. A fully erupted tooth will have less of a tuberosity in comparison with a partially or unerupted upper third molar tooth. This becomes even more challenging when the patient opens the mouth wide. Placing an elevator or

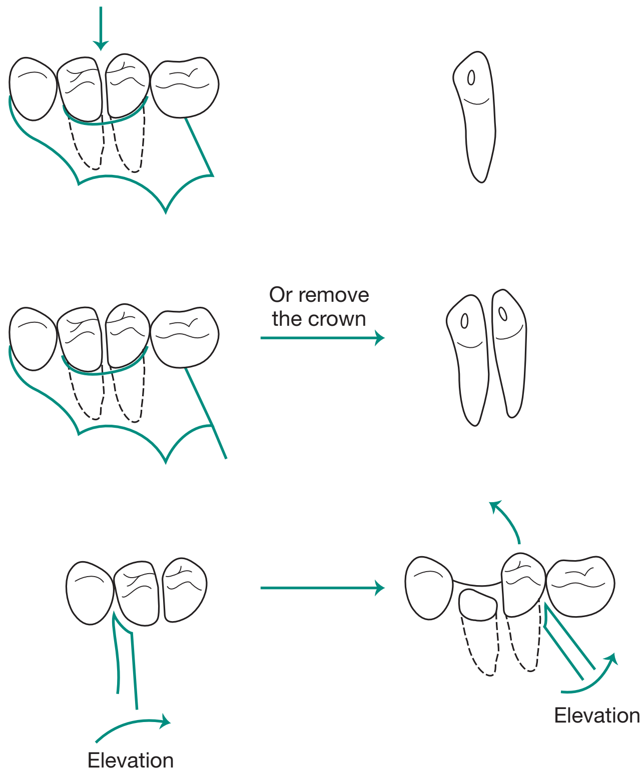


Figure 5.8 Lower molar surgical extraction. Similar to **Figure 5.7**, three different flaps can be used to gain access to remove the roots. Here, a two-sided flap with a distal relieving incision has been used to create a bony gutter to allow elevation of the roots.

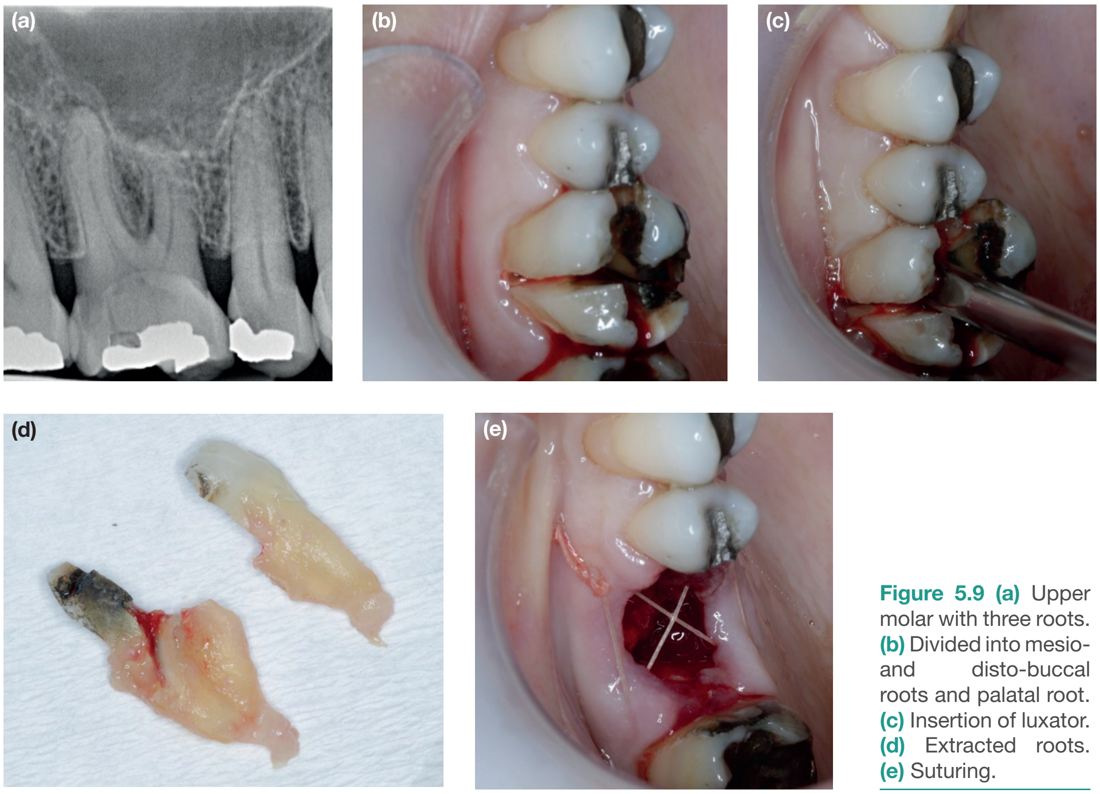


Figure 5.9 **(a)** Upper molar with three roots. **(b)** Divided into mesio- and disto-buccal roots and palatal root. **(c)** Insertion of luxator. **(d)** Extracted roots. **(e)** Suturing.

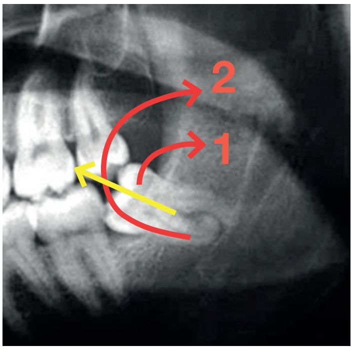


Figure 5.12 Planning for a two-rooted mesio-angular tooth, option 1.

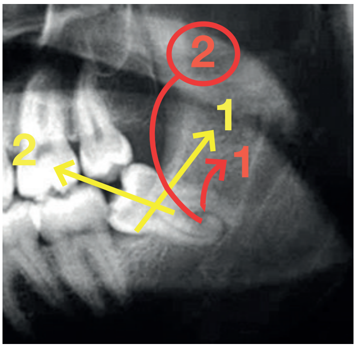


Figure 5.13 Planning for a two-rooted mesio-angular tooth, option 2.

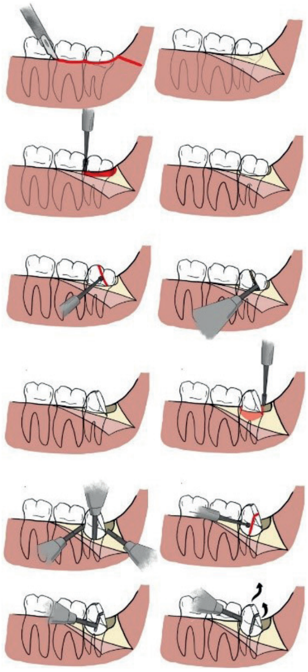


Figure 5.14 Surgical planning for a two-rooted disto-angular wisdom tooth.

- Option 2 (***Figure 5.13***)
  - Horizontal sectioning of the crown to separate it from the roots (yellow line 1). First cut (yellow line 1) must be executed to create a smaller mesial and larger distal half to ensure the crown does not wedge itself. This cut is often challenging to perform due to reduced access on mesio-angular or horizontally impacted wisdom teeth

A similar plan can be applied to both mesio-angular and horizontally impacted teeth. In a disto-angularly impacted tooth, there is a lack of elevation point in the mesial aspect due to lack of bone in between the second and third molars. Secondly, the distal and cervical bone is embedded underneath the distal part of the crown. Hence, the distal part of the crown must be removed to access this bone (***Figure 5.14***) and subsequently, guttering of this bone allows elevation of the tooth (***Figures 5.15*** and ***5.16***).

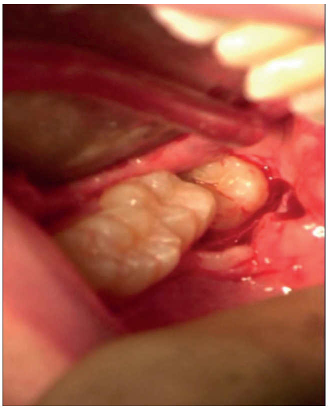


Figure 5.15 Envelope flap with a distal releasing incision.

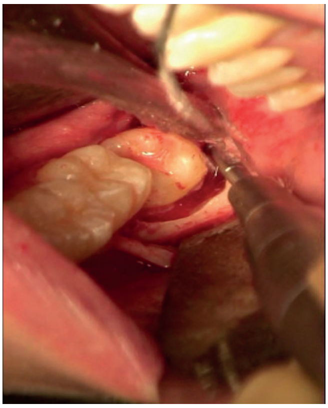


Figure 5.16 A buccal bony gutter to show adequate cortical bone has been removed.

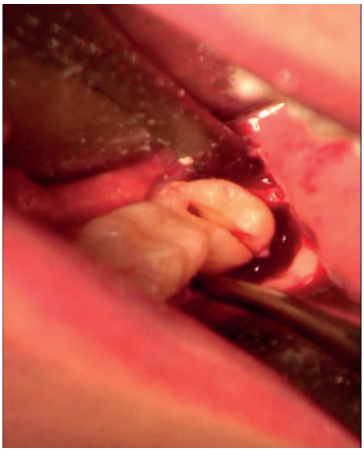


Figure 5.17 Vertical splitting of the crown to divide the wisdom tooth into mesial and distal halves for easier removal.

When there are two roots, often a separate vertical sectioning may be needed to separate the roots (*Figure 5.17*). If the crown is sectioned entirely, careful buccal bone removal can be done distal and buccal to the second molar to visualise and achieve an elevation point.

Ankylosed deciduous teeth

The prevalence of ankylosis and infra-occlusion in primary molars is between 8% and 14% in children aged 6–11 years. Distal tipping of the premolar and mesial tipping of the first molar often occurs when the deciduous tooth submerges under the oral mucosa, resulting in reduced surgical access.

As these teeth are ankylosed to the bone without any periodontal ligament space, often the root fractures at the junction of root/bone interface. This either can be left alone for spontaneous resorption or a rose head bur can be used to remove the root/non-bleeding bone. Gentle oozing confirms that the root has been removed. If the ankylosed root has been left behind, it is important to communicate this with the orthodontist as they are likely to see a radiopaque material on any radiographic images close to root of the teeth which are planned to be mobilised orthodontically.

SURGICAL EXPOSURES OF TEETH/CANINES

An impacted tooth can be defined as a tooth whose eruption is considerably delayed, and clinically or radiologically they are located away from the expected final position. With the exception of the third molars, upper canines are the most commonly impacted teeth, with a reported frequency of between 0.8% and 3%. Other commonly impacted teeth include upper central incisors and second premolars.

Surgical exposure for palatally impacted teeth

If an exposure of a palatally impacted tooth is indicated, there are three common surgical approaches: closed exposure with bracket and chain, open exposure without bracket and chain and open exposure with bracket and chain.

Closed exposure

A mucoperiosteal flap is raised and the tissues (thin bone and follicle) overlying the impacted tooth are removed. A low-profile orthodontic bracket with a gold chain is bonded to the crown of the tooth, preferably with a light cured composite. Placement of the bracket should be done on the most accessible surface of the tooth. Every effort should be made to avoid placing the bracket on the labial aspect to avoid fenestration of the labial cortical bone and the labial attached gingiva on orthodontic alignment of the tooth.

Figure 5.18a shows a palatal bulge prior to exposure of an impacted palatal canine, and in *Figure 5.18b* a mucoperiosteal flap has been raised. A 3-mm chisel has been used to carve the surrounding bone to expose the tooth. Care must be taken not to remove the bone below the cemento-enamel junction of the tooth as this may cause periodontal attachment problems in the long term. Also, as follicle aids formation of healthy junctional epithelium, care must be taken not to remove follicle on mesial and distal aspects of the canine. Excessive curettage of the follicle may result in recession of the exposed tooth or the adjacent tooth. Once the bracket is bonded to the tooth with a light cure composite, the chain needs to be immobilised to the arch wire with a suture (*Figure 5.18c*). The wound is then closed with resorbable sutures (*Figure 5.18d*).

Open exposure

The overlying mucosa and bone are removed to expose the underlying crown of the tooth. This can be done by excising the mucosa immediately overlying the impacted tooth (gingival-sparing procedure) and the bone without raising a flap (*Figure 5.18e*). Or, alternatively, a flap can be raised as described for a closed exposure and the overlying mucosa excised (*Figure 5.18f*). A straight artery clip is used to hold the mucosa and a blade used to excise the mucosa. A wedge of tissue can then be excised to the width of the size of the tooth (*Figure 5.18g*). Bipolar diathermy is used to achieve haemostasis.

A summary of the advantages and disadvantages of open versus closed exposure of the canines is given in *Table 5.1*.

Labially impacted teeth: apically repositioned flap

Unlike palatally impacted teeth where the mucosal surface is entirely lined by keratinised epithelium, labial