The Upper Jaw ("Midface") and Sinuses: Part I

18

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18.1 Applied Anatomy and Physiology

The term "midface" is more of a clinical than an anatomical term, which is variably applied to the face. It is often used to refer to those structures comprising that part of the face which is situated between the base of the skull (loosely approximating to the eyebrows) and the upper teeth (that is, the cheeks, nose, paranasal sinuses and orbits). To complicate matters, this region may be further divided into a 'central midface', 'lateral midface' and an 'upper midface'. Thus many structures are involved and interrelated. However in an effort to keep things simplified, for the purposes of this chapter the nose, cheek and orbit are not discussed. These structures have their own respective chapters. Nevertheless, with such a complex and varied anatomical region there will of course be some degree of overlap between these sites, anatomically, pathologically, clinically and radiologically. Diseases and injuries in one anatomical region can often extend into another, resulting in seemingly unrelated symptoms and the risk of misdiagnosis. Septal problems can result in sinusitis. Sinusitis can result in nasal discharge. Sinus tumours can affect the eye. Midface fractures can result in blindness and nasal bleeding. All symptoms therefore need to be carefully evaluated.

18.1.1 The Upper Jaw

Terminology here can also be a little confusing and is often applied inconsistently. This structure is sometimes referred to clinically as the "maxilla", although anatomically the maxillae (the right and left maxillary bones) only form part of the

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entire upper jaw. The 'upper jaw' as a functional unit is anatomically a complex structure composed of a number of very different bones. These are

(i) 2 Maxillae
(ii) 2 Palatine bones and
(iii) the pterygoid plates of the sphenoid

This functional structure supports the upper teeth. The remainder of the 'mid-face' is made up of

(iv) 2 Inferior conchae
(v) Ethmoid vomer
(vi) 2 Lacrimal bones
(vii) 2 Zygomatic processes of the temporal bones
(viii) 2 Zygomas
(ix) 2 Nasal bones

The entire structure (midface) acts to support the globes, separate the oral and nasal cavities and resist the heavy forces of mastication that occur during chewing, between the skull base and the teeth.

Embryologically the maxillary bones are derived from the maxillary processes of the first arch. Together with the intermaxillary segment, these fuse in the midline. Thus in the adult the two maxillary bones are fused together in the midline. These bones support the teeth and together with the palatine bones and soft palate, separate the oral cavity from the nasal cavity. This is crucial for proper function and development of the face. Facial clefting can involve the maxillary and other processes, during embryonic development, resulting in varying degrees of incomplete fusion between any of the five facial prominences. This can be partial or total, unilateral or bilateral. The commonest clefting anomalies are cleft lip and the cleft palate, which occurs when the maxillary prominence fails to fuse with each other and/or the intermaxillary processes.

The maxillary bones also make up a significant part of the lateral wall of the nasal cavity, part of the infraorbital rim and the orbital floor. The maxillary sinus (antrum) sits within each maxilla and is variably sized. This is a hollow gas-filled, pyramidal-shape structure, with its base facing towards the nasal cavity and its apex towards the zygoma (laterally). Some of the bones surrounding the sinus are quite thick, comprising two of the vertical 'buttresses' of the facial skeleton. These play an important role in resisting biting forces. It is probably through the action of wolfs law that the sinuses exist (i.e. bone that is not physiologically required atrophies and resorbs). The lateral wall of the maxillary sinus curves upwards to join the zygomatic bone to form the lateral or zygomatic buttress.

The maxillary sinus has a roof, floor, anterior, posterior and medial wall. These have important and intimate anatomical relationships with adjacent structures. The roof of the sinus is the floor of the orbit. This bone is very delicate and is often a site of fracture following impacts to the cheek (zygoma) or globe. The orbital floor is traversed by the infraorbital nerve and vessels, passing through the infra orbital canal. This is often seen during orbital surgery, or endoscopy of the sinus, as a ridge running forwards towards the anterior sinus wall. The maxillary sinus floor is composed of a thin layer of cortical bone into which the roots of the molar (and some premolar) teeth project. In some patients this bone may even become perforated. Dental infections can therefore mimic or precipitate acute sinusitis and sinus pathology can sometimes present as 'toothache'.

Medially, the sinus opens high on the lateral nasal wall, just below the ethmoidal bulla. The openings for the frontal and anterior ethmoid sinuses are also found here. This is referred to as the 'ostium'. Each sinus has its own specific drainage route before passing through the ostium into the superior or medial meatus. The anterior ethmoid, frontal and maxillary sinuses drain into the middle meatus and the posterior ethmoid and sphenoid sinuses drain into the superior meatus. The various drainage channels can all, or separately be involved in infections, trauma or tumours, resulting in impaired sinus drainage, retained mucus secretions and the risk of infection. The anterior wall of the sinus is thin and through it exits the infraorbital nerve and vessels. The bone here provides attachment for some of the facial muscles. Posteriorly, the wall fuses with the pterygoid plates and transmits the posterior superior alveolar vessels and nerves to supply the upper teeth. Each sinus is lined by mucoperosteum, comprised of ciliated columnar epithelium and mucous producing cells. The cilia beat towards the ostium thus ensuring drainage of the sinus. This membrane is sometimes referred to as the "Schneiderian Membrane". Ohngren's line is an important virtual anatomical plane used in head and neck cancer, specifically in relation to cancers of the sinuses. It extends from the medial canthus to the mandibular angle. Maxillary tumours sited, or extending above this line have a poorer prognosis than those below it. This is because of the proximity to the orbit and cranial cavity (Figs. 18.1 and 18.2).

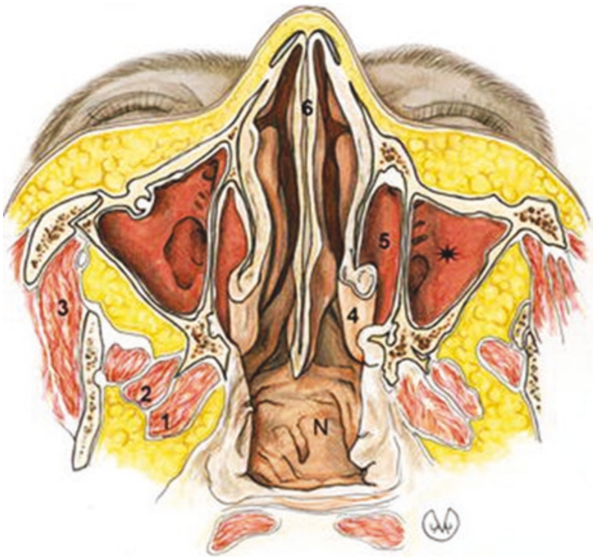

Fig. 18.1 Anatomy of nasal cavities and maxillary sinuses, caudal view. Medial pterygoid muscle (1), lateral pterygoid muscle (2), masseter (3), inferior turbinate (4), inferior meatus (5), nasal septum (6). Nasopharynx (N), maxillary sinus (asterisk)

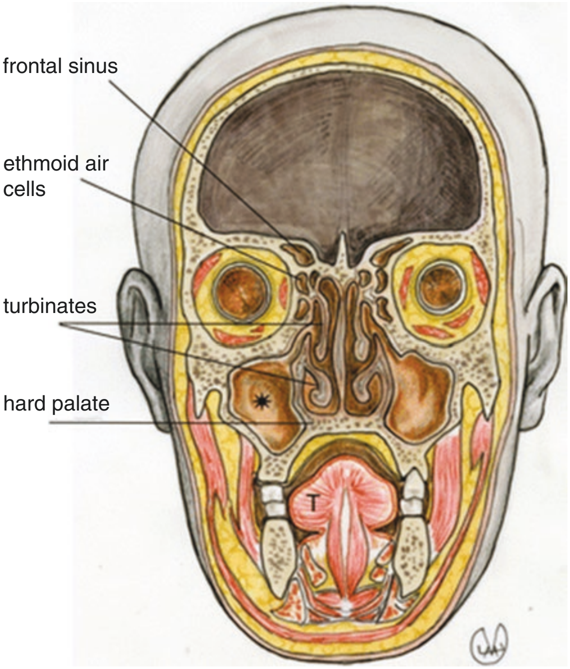

Fig. 18.2 Anatomy of the facial skeleton, coronal section. Tongue (T), maxillary sinus (star)

The overall arrangement of all the midface bones, together with the presence of the nasal, sinus and orbital cavities, effectively converts the midface into a series of vertical and horizontal bony struts known as the "buttresses". This is important in the repair of midface trauma. The vertical buttresses pass upwards from the teeth and fuse with the skull base. Three major vertical buttresses have been described

1. Anterior—These form the piriform fossa, lateral to the nose passing into the frontonasal process.
2. Middle—This is formed by the buttress of the zygoma passing between the maxilla inferiorly and the frontal bone above.
3. Posterior—This is made up of the pertygoid plates attaching to the base of the skull.

It has been shown that these bones are very good at supporting the load of any vertical applied force (i.e. during biting). However the buttresses are thinner horizontally and therefore less good at resisting horizontal impacts—a significant vector during most injuries. Interestingly, the mechanical arrangement of the facial skeleton has been likened to the chassis of a car. At the moment of impact, the horizontal struts (buttresses) collapse, thereby preventing the kinetic energy form being transferred to the brain (the 'driver'). Effectively, it is argued, the facial skeleton has evolved into a "crumple zone". The midface sits on an inclined skull base (at 45 degrees to the horizontal plane) and therefore following impact the bones can crumple along this plane, in a downwards and backwards direction. Clinically this results in an elongated face and a deranged bite, where the back teeth meet prematurely (anterior open bite). Despite this survival advantage, the combination of extensive vascularity of the face and its lack of deep fascia can still result in significant blood loss, swelling and airway compromise (particularly in the supine patient) (Fig. 18.3).

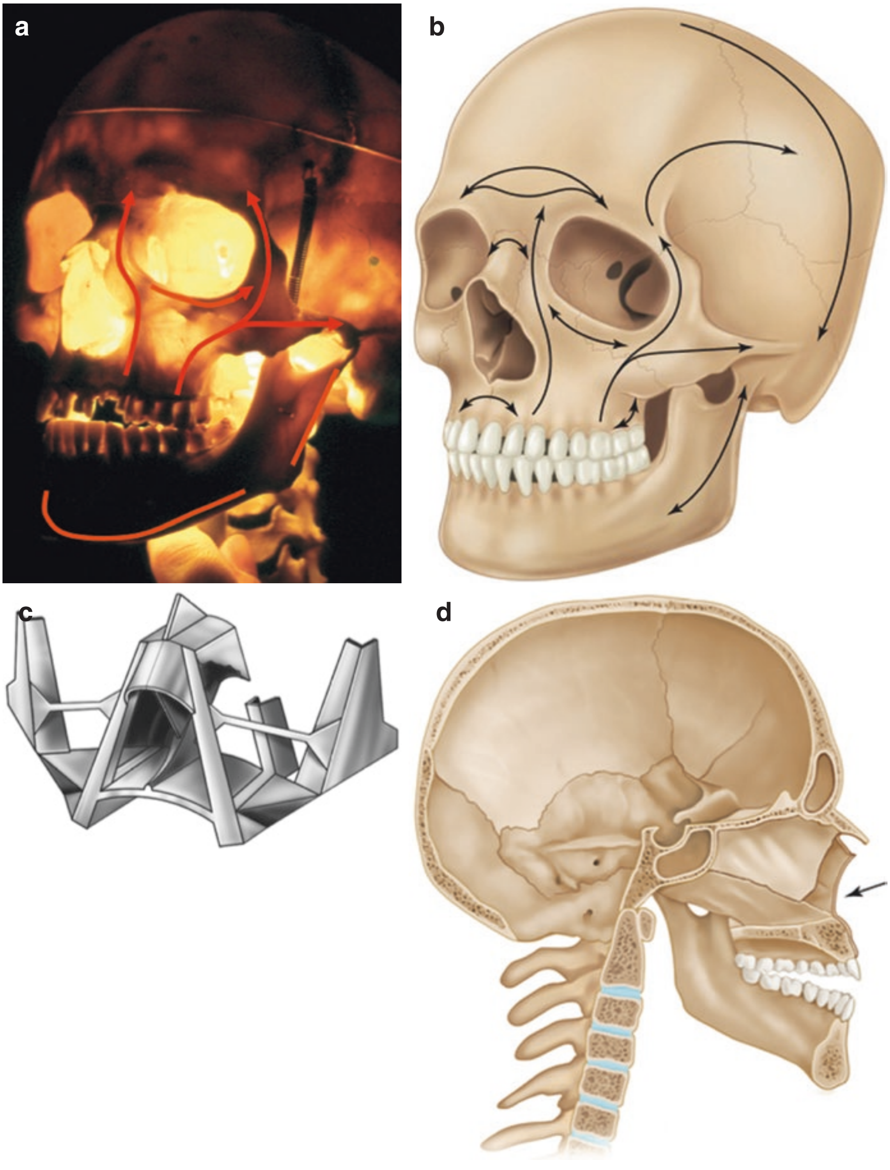

Fig. 18.3 (**a**–**d**) The overall arrangement of all the midface bones, together with the presence of the nasal, sinus and orbital cavities, effectively converts the midface into a series of vertical and horizontal bony struts known as the "buttresses"

18.1.1.1 Development of Paranasal Air Sinuses

The paranasal air sinuses develop as diverticulae from the walls of the nasal cavities. These grow into the maxilla, ethmoid, frontal and sphenoid, becoming air filled as they enlarge. The initial openings of the diverticulae persist as the orifices of the adult sinuses (Fig. 18.4).

18.1.2 The Soft Tissues

The soft tissues of the midface form a complex anatomical area often referred to as the 'soft tissue envelop'. This contains not only skin and muscle, but also fat, nerves, lymphatics and blood vessels, all of which may be variably affected by

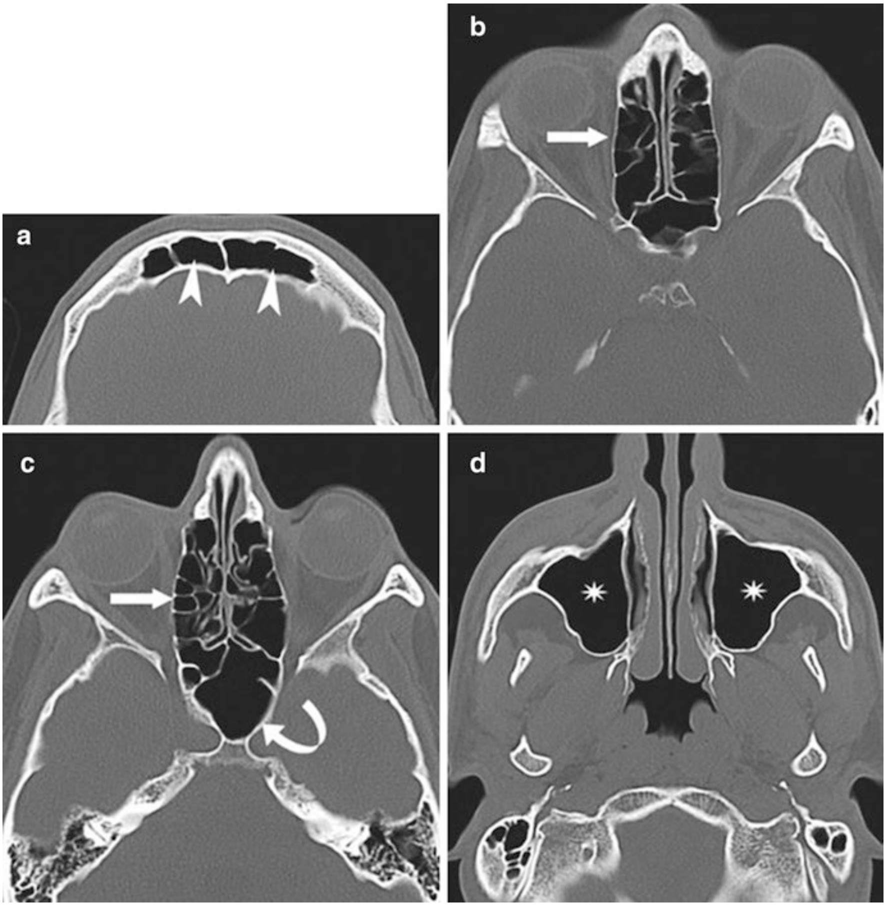

Fig. 18.4 Paranasal cavities CT, axial scan, with high-spatial-frequency (bone) reconstruction algorithm. (**a**) Frontal sinuses (*arrowhead*). (**b**) Ethmoid cells (*arrow*). (**c**) Ethmoid cells (*arrow*) and sphenoid sinus (*curved arrow*), (**d**) Maxillary sinus (*asterisks*)

disease or trauma. Fat necrosis, for example, can occur under intact skin following blunt trauma. Lymphedema around the lower eyelids can take many months to resolve. Together, these tissues are important in protecting the eyes, the nasal cavity and the oral cavity, by their sphincteric actions, as well as playing a role in facial expression, symmetry and aesthetics. The superficial musculoaponeurotic system (SMAS) is a supporting mechanism for this envelop. This is a continuous layer which passes from the frontalis muscle in the upper face to the platysma in the neck. It forms the 'investing fascial layer' of the orbicularis occuli, zygomaticus muscles and muscles of the upper lip. It also inserts into the skin at the nasolabial fold. Lateral to the nasolabial fold is the malar fat pad. This overall arrangement results in a number of fascial planes that are important in determining the spread of facial infections and also when planning drainage of facial abscesses. The fascial tissues will initially contain oedema, inflammation and pus to a specific site or 'tissue space'. However, once breached, infection can then rapidly spread throughout the adjacent space.

The facial muscles within the midface are the (i) levator labii superioris, (ii) levator anguli oris (caninus), (iii) depressor septii, (iv) zygomatic major and minor, (v) orbicularis oris and (vi) buccinators. These muscles are innervated by branches of the facial nerve. Their blood supply is mainly from the facial and maxillary arteries and veins. The functions of these muscles are.

(i) The Caninus or levator anguli oris. This originates near the upper jaw bone near the canine and insets near the corner of the mouth. This pulls the upper lip in a vertical direction. It is innervated by the zygomatic and buccal branches of the facial nerve (VII).
(ii) The Buccinator. This originates in the maxilla and mandible in the region of the molar teeth and inserts into various muscles at the corner of the mouth. It acts to compress the cheeks tight against the teeth, and to tighten and pull the corners of the lips inwards and laterally, often dimpling the cheeks. This muscle forms a large part of the lateral wall of the mouth. Its functions helps to keep food in the mouth during mastication (chewing). The buccinator is innervated by the buccal branche of the facial nerve (VII).
(iii) The Depressor septi. This is a small muscle in the upper lip originating in the upper jaw and inserting into the nasal septum and ala of the nose. It acts to lower the septum and nostrils, thereby changing the shape of the nasal tip, narrowing and lengthening it. It is innervated by the lower zygomatic and buccal branches of the facial nerve (VII)
(iv) Zygomatic major. This originates in the cheek bone (zygomatic arch) and inserts into other muscles (orbicularis oris, depressor, etc.) near the corner of the mouth. This muscle lifts the corner of the mouth obliquely upwards and laterally. It is therefore an important muscle in smiling. Some research suggests that the difference between a genuine smile and a perfunctory (or lying) smile is that when a person genuinely smiles, Zygomatic major contracts with orbicularis oculi. Zygomatic major is innervated by the zygomatic and buccal branches of the facial nerve (VII).

(v) Orbicularis oris. This is the sphincter muscle around the mouth, forming much of the bulk of the lips. It has extensive connections to the other muscles that converge on the mouth. This muscle acts to shape and control the size of the opening of the mouth and is important for creating lip movements during eating and speech. Orbicularis oris is innervated by the lower zygomatic, buccal and mandibular branches of the facial nerve (VII)

18.1.3 Blood Supply

The midface is a highly vascular structure. Together with the lack of deep fascia this makes it very prone to rapid swelling following injury or in the presence of infection. The main arterial branches supplying this region include

(vi) Palatine artery
(vii) Infraorbital artery
(viii) Maxillary artery
(ix) Facial artery
(x) Nasopalatine artery

The veins essentially follow the arterial pattern. However they also communicate directly with the cavernous sinus via the orbit. This enables the potential spread of infected emboli intracranially with the potential for cavernous sinus thrombosis (see the chapter on the head). In addition, the pterygoid venous plexus also communicates with the cavernous sinus, by branches that pass through the foramen ovale, and foramen lacerum. This plexus is an extensive network of valveless veins on the lateral aspect of the medial pterygoid muscle and within the infratemporal fossa. It has extensive connections with the facial vein, inferior ophthalmic vein, maxillary vein, pharyngeal venous plexus and cavernous sinus.

18.1.3.1 Aseptic Necrosis of the Maxilla

Aseptic necrosis of the maxilla following trauma is a rare complication. Only a few reports have been published describing necrosis of the maxilla after fracture. This is believed to occur when the vascularity has been compromised and therefore is more likely following high energy injuries. Necrosis can also occur following surgical repositioning of the upper jaw (osteotomy), infection, tumour and radiotherapy. The blood supply to the maxilla arises predominantly from the palatine artery and internal maxillary arteries.

Causes of osteonecrosis can be classified into septic and aseptic necrosis. Septic osteonecrosis can occur as a result of local infections, notably fungal infections such as mucormycosis and aspergillosis, which commonly result in thrombosis within the vessels. Viral infections (such as herpes zoster) in immunocompromised patients, have also been reported to result in osteonecrosis. Malignancy and radiation can result in aseptic necrosis of the maxilla as a result on invasion of the bone, or the development of endarteritis obliterans. Following jaw surgery (osteotomy), ischaemia is a rare complication presumably as a result of division of vessels and peritoneal dissection. Lesser-known causes of osteonecrosis include Wegener's granulomatosis, acute necrotising ulcerative gingivitis and Gorham's disease (a rare disorder of unknown aetiology that results in destruction and resorption of bone from proliferation of non-neolastic vascular or lymphamatous tissue).

18.2 Nerve Supply

18.2.1 The Trigeminal, Maxillary and Infraorbital Nerves

The trigeminal nerve transmits sensation from the skin of the front of the head and face, the oral and nasal cavities, the teeth and the meninges. It is the largest of the cranial nerves. It has three major divisions (ophthalmic, maxillary and mandibular) which are usually described as separate nerves. The mandibular division also carries motor fibres to the muscles of mastication (used in chewing). The nucleus of the trigeminal nerve is located in the midpons. The nerve originates from three sensory nuclei (mesencephalic, principal sensory and spinal nuclei) and one motor nucleus which extend from the midbrain to the medulla. At the level of the pons, the sensory nuclei merge to form a sensory root. This and the motor root are analogous to the dorsal and ventral roots of the spinal cord. From here the nerve passes forward along the middle cranial fossa. As it does, the sensory root expands to become the trigeminal ganglion.

The trigeminal ganglion is sited in a small depression in the middle cranial fossa lateral to the cavernous sinus—the trigeminal or Meckel's, cave. This is partially surrounded by cerebrospinal fluid in a small recess in the subarachnoid space. The ganglion splits into its ophthalmic (Va), maxillary (Vb) and mandibular (Vc) divisions. Within it are the cell bodies of the primary sensory neurons from all of these divisions, except proprioceptive neurones. The maxillary nerve passes forwards to the pterygopalatine fossa where it divides into two main branches (the infraorbital and zygomatic), and gives off other branches to the nose, palate and upper teeth. The maxillary nerve transmits sensory fibres from the skin of the front of the face (between the lower eyelid and the mouth), from the nasal cavity and sinuses, and from the maxillary teeth. Some of its branches contain postganglionic parasympathetic fibres from the pterygopalatine ganglion. These pass to the lacrimal, nasal and palatine glands, while other branches convey taste from the palate.

The infraorbital nerve is the main terminal branch of the maxillary nerve. This passes anteriorly along the floor of the orbit in the infraorbital groove. It gives off branches to the mucosal lining of maxillary sinus. The nerve then emerges through the infraorbital foramen to supply the skin over cheek and upper lip. Other branches from the maxillary nerve include

(xi) The zygomatic nerve. This enters the orbit through the inferior orbital fissure. It gives off two small branches which penetrate the zygoma (zygomaticofacial and zygomaticotemporal) to provide sensation to a small patch of skin over the prominence of the cheek. The zygomatic nerve also conveys post-ganglionic parasympathetic fibres from the pterygopalatine ganglion to the lacrimal gland.

(xii) Nasal branches. These pass through the sphenopalatine foramen into the nasal cavity to supply the cavity and sinuses. Branches also convey postganglionic parasympathetic fibres from pterygopalatine ganglion to the nasal glands.

(xiii) Superior alveolar (dental) nerves. Branches of the infraorbital and palatine nerves pass directly through maxilla to supply the maxillary teeth, gums and sinus floor.

(xiv) Greater and lesser palatine nerves. These provide sensation to the hard and soft palate. Branches also convey postganglionic parasympathetic fibres from pterygopalatine ganglion to minor salivary glands in the palatal mucosa.

(xv) Pharyngeal branch. This passes posteriorly to contribute to the sensory supply of nasopharynx.

Knowledge of this anatomy can help in the diagnostic process. For example, trauma to the infraorbital margin or orbital floor may result in sensory loss to the skin over the front of the face. This is an important clue when assessing orbital and zygomatic fractures. Maxillary sinusitis may result in pain referred to the infraorbital region or present as toothache (especially the upper molar teeth). Malignant tumours of sinus may erode or infiltrate into the infraorbital nerve resulting in anaesthesia over the facial skin.

18.3 Anatomy and Physiology of Facial Pain

This is a very complex subject and often a difficult diagnostic problem. Understanding the anatomy, physiology and pathology of pain pathways can help in the assessment and management of some of the complicated pain syndromes, described later in this chapter. The body's somatosensory system enables the perception of touch, pressure, pain, temperature, position, movement and vibration. The somatosensory nerves arise in the skin, muscles, joints and fascia and include thermoreceptors, mechanoreceptors, chemoreceptors, pruriceptors and nociceptors. These send signals to the spinal cord and eventually to the brain for further processing. Most sensory pathways involve the thalamic nucleus which process and direct the signal to the cerebral cortex. Thus, lesions or diseases of the somatosensory system can result in altered and disordered transmission of signals. Common conditions that are associated with 'neuropathic' pain through varying mechanisms include postherpetic neuralgia, trigeminal neuralgia, radiculopathy, diabetic neuropathy, HIV infection, leprosy, peripheral nerve injury pain and stroke. The anatomy of facial pain (and headaches) is very complicated and entire chapters and books have been written, devoted to this subject. This is in part due to the complex embryology of head and neck development. The upper cervical nerves carrying painful sensations from the back of the head and the neck converge with the trigeminal sensory neurones in the dorsal horn of the spinal cord to form the 'trigeminocervical complex'. Neurones in this complex are the major relay neurones for nociceptive (painful) stimuli from the meninges and cervical structures. This is the reason why pain from the neck can be referred to the face and head. Although facial sensation is principally from the trigeminal nerve, there is some contribution also from the facial nerve and vagus nerve.

Several classifications of pain are currently used in diagnosis. One common system considered pain as

(i) Nociceptive—this represents the normal response to a noxious stimulus or injury to the tissues such as skin, muscles, visceral organs, joints, tendons, or bones. Somatic pain can be musculoskeletal (joint pain, myofascial pain) or cutaneous and is often well localised. This is pain that arises in structures which one is generally aware of (skin, oral mucosa, joints etc.). The pain is usually described as sharp, or sore and often subsides following healing. Visceral pain involves the hollow organs and smooth muscle. This is usually referred elsewhere.

(ii) Neuropathic pain is initiated or caused by a primary lesion or disease involving the somatosensory nervous system, including both peripheral fibres and central neurones. Including sites beyond the head and neck, it affects around 10% of the general population. Sensory abnormalities may be associated and range numbness to hypersensitivity (hyperalgesia or allodynia), to paresthesias (tingling). Examples include diabetic neuropathy, postherpetic neuralgia, spinal cord injury pain, phantom limb (post-amputation) pain, and post-stroke central pain. This pain can persist long after healing has taken place. It is often described as burning, shooting, or like an electric shock. Injury can occur peripherally or centrally, anywhere along the neural pathway, for example following herpes zoster infection ("post herpetic neuralgia"). Conditions that can result in neuropathy include trauma, inflammatory autoimmune disorders (e.g. systemic scleroderma, Sjogren's syndrome, sarcoidosis, multiple sclerosis); rare vascular malformations, neoplasia anywhere along the trigeminal nerve and infections such as leprosy, viral, Lyme disease and syphilis. Imbalances between excitatory and inhibitory somatosensory signalling, alterations in ion channels and variability in the way that pain messages are modulated in the central nervous system all have been implicated in neuropathic pain.

(iii) Inflammatory pain occurs as a result of activation and sensitisation of the nociceptive pain pathway by a variety of mediators released at the site of tissue inflammation. These have been implicated as key components to the perception of pain and include cytokines such IL-1-alpha, IL-1-beta, IL-6 and TNF-alpha, chemokines, reactive oxygen species, vasoactive amines, lipids, ATP, acid, and other factors released by infiltrating leukocytes, vascular endothelial cells, or tissue resident mast cells. Inflammatory pain may be seen in appendicitis, rheumatoid arthritis, inflammatory bowel disease, and herpes zoster.

(iv) Deafferentation. This type of pain results in partial or total loss of sensation in a localised area following loss or impairment of the sensory fibres. Instead of a decrease in pain sensation in the affected area, spontaneous pain may develop. This is called “dysaesthesia” and may be seen, for example, following injury to the inferior alveolar or lingual nerve (most commonly after wisdom tooth removal)

(v) Allodynia. This is pain caused by stimuli that would normally not produce pain, e.g. bedclothes producing a burning sensation or shaving causing severe facial pain.

Shingles and Varicella-Zoster The trigeminal ganglion is a common site for infection by the herpes zoster virus, resulting in shingles. This causes a painful vesicular eruption in the sensory distribution of the nerve. The virus can remain latent in the ganglion following chickenpox for many years before reactivation.

18.3.1 The Role of the Midface in Airway Maintenance, Speech and Swallowing

The upper jaw plays a key role in maintaining the airway and enabling normal speech and swallowing. Not only does it comprise part of the rigid nasal cavity (the nasal floor), but it also provides a firm roof to the oral cavity, which enables articulation and the early stages of swallowing. Not surprisingly therefore diseases and injuries to the upper jaw can have a profound impact on these functions. Defects in the hard palate (either from trauma, malignancy, or inflammatory conditions such as Wegeners granulomatosis) can dramatically affect the ability to eat and drink and talk. In children with cleft palate, this can also have similar effects. Surgical repair of the cleft can also result in adverse effects on subsequent facial growth. Conversely, lumps and swellings arising from the midface can extend into the oral cavity, nasal cavity and even reach as far as the orbit. Displacement and obstruction within these structures can reduce a wide range of symptoms, some of which may not be immediately apparent to be arising from the upper jaw.

Lack of midface protrusion can result in a characteristic appearance of the face and can adversely affect the patients bite. In some patients this can contribute to snoring and obstructive sleep apnoea. Surgical advancement of the midface is a major part of modern day maxillofacial surgery and can be undertaken in conjunction with surgery to reposition the lower jaw. Such repositioning procedures require careful planning as they can significantly affect the patients bite, speech and ability to eat and swallow food for better or for worse. When planning such procedures the impact on the soft palate should also be remembered as this will be advanced forwards along with the maxilla. Generally speaking however, this does not usually results in a clinical problem, the exception being large maxillary advancements in cleft palate patients.

As we loose teeth, the supporting alveolar bone naturally resorbs over time. This can be accelerated if all the upper teeth have been removed and the patient where is a poorly fitting upper denture. This can be a common cause for complaints and oral discomfort and is discussed further in the chapter on the mouth. Implant retained dental prostheses, either single teeth or multiple teeth is another area of modern maxillofacial, oral surgery and dental practice. This also requires considerable careful planning. Whilst in principle, placement of implants is a straightforward procedure, they are expensive and patient selection is very important.

18.4 Important Considerations When Taking a History

Symptoms related to midface and sinus pathology often overlap with symptoms related to nearby structures. Patients may therefore present with symptoms which may initially suggest problems with the mouth, teeth, nose, eyes or overlying skin. Because of its widespread innervation from the trigeminal nerve, referred pain can also masquerade as pathology elsewhere. The history may therefore need to be 'tailored' according to the patient's initial presenting features. These commonly include pain, swelling and numbness, although ocular, nasal, dental and oral symptoms may also occur frequently. These latter symptoms are discussed in their relevant chapters.

Infections commonly occur in the midface. These can arise from a variety of sources, most commonly the skin (abscesses, cellulitis, shingles), sinuses and teeth. As with all infections it is important to determine the rate of progression, extent and presence of systemic symptoms. Toothache, recent dental treatment or dental injury, will suggest an underlined dental course, which may require urgent treatment. Unilateral nasal discharge will suggest a sinus infection. Swelling (especially of the lower eyelid) and numbness of the cheek suggest that the infection is becoming extensive and may require admission. Swelling of the midface is rarely an airway threatening problem, but may still represent a serious infection.

Patients who present with midface trauma need careful evaluation. This is discussed further in the chapter on the injured patient. Midface trauma can result in airway difficulty and significant blood loss. Fractures may extend beyond the central part of the face to involve the orbits and possibly even the skull base. The mechanism of injury is thus very important. Any loss of consciousness is important due to the risk of significant brain injury. Any deterioration in the level of consciousness, together with progressive swelling and bleeding from the midface should raise immediate concerns regarding airway protection. Lost or loose teeth, numbness of the cheek, double vision, or a change in the bite are all suggestive of the possibility of fracture. Careful assessment of the hard palate, teeth, orbit and nose is therefore also an important part of the examination.

Facial pain is a common problem and frequently involves the midface. In most cases where there is serious pathology, symptoms will be unilateral, although sinusitis can results in bilateral discomfort. It is important to determine whether the pain is generalised or dermatomal in distribution, the latter implies nerve or nerve root irritation, which requires careful evaluation. Some skull base tumours can present with unilateral pain or numbness involving the midface. Associated symptoms such as swelling, facial weakness, a dermatomal rash (shingles) or a history of recent injury or dental treatment should be elicited. Similarly, unilateral weakness of the face should be assessed along similar lines.

Swellings of the midface also have many diverse causes and can range from simple benign cysts to late presentation of malignancy. With any lump or swelling it is important to determine whether this is slow-growing or rapidly expanding, associated with symptoms of infection and whether it is painful or painless. A swelling that is associated with numbness (infraorbital nerve), facial weakness or distortion of anatomy implies involvement of the bone. Any prior history of toothache may be important. A painful tooth that becomes painless may indicate that the tooth has died—but the infected pulp chamber is still there and can act as a focus for infection and cystic change, sometimes much later.

18.5 Examining the Midface and Associated Structures

Examination of the midface is rarely undertaken in isolation and should be regarded as one feature of the examination of the entire face. A through examination must include examination of the oral cavity and upper teeth, lower jaw, nasal cavity and the orbit (as detailed in their respective chapters). With major injuries to the face, initial assessment follows the lines of ATLS as discussed in the chapter on the injured patients. What follows here is a description of assessment of the 'walking wounded' patient, or patients presenting with non-traumatic pathology. Whilst these are usually not clinically urgent, the first step is always to consider the patient's "ABC".

Initially the entire face should be inspected from both the front and the side of the patient, noting any asymmetry, weakness, swelling, discolouration or signs of injury. If there is any orbital involvement, early assessment of the eye is important—often this assessment takes priority. The relationship between the height of the face and its width is important in facial harmony and attractiveness. When looking at someone we subconsciously notice this, taking into account the person's age and ethnicity. When viewed from the front, the face can be divided into approximately equal sized fifths by a series of vertical lines. These are (i) from the lateral facial contour to the outer canthus of the eye, (ii) from the outer to the inner canthus of the eye and (iii) between the two inner canthi (the intercanthal distance). This latter distance should be assessed carefully following trauma to the upper face, forehead or nose as any increase in width may indicate significant fractures. Injuries and tumours in the nasoethmoid region can widen the intercanthal distance.

The facial profile should also be viewed. However this can vary between different individuals and different ethnic groups (as can intercanthal distance). Flattening can occur following localised impacts (especially in the elderly). Any localised forward expansion may suggest infection, cystic change or bony pathology, including tumours. Changes in skin colour, especially bruising or erythema should be noted. Swellings should be examined both externally and intraorally, and if necessary, intranasally. Cysts related to the teeth are a common cause of swelling in the upper jaw. Examine these gently as cysts in the upper jaw can sometimes be covered by just a thin layer of bone. They may deceptively feel like soft tissue cysts, rather than cysts arising within bone. Cysts can present with or without infection. They can vary greatly in size and may be palpable within the mouth, either in the upper buccal

Fig. 18.5 Intraoral examination is an integral part of midface examination

sulcus (between the soft tissues of the cheeks and teeth), or be seen bulging into the palate (within the oral cavity). CT imaging is therefore often required to assess their extent. The teeth themselves will also need to be assessed. This aspect of the examination is described in the relevant chapter. Some cysts or tumours may also expand into the nasal cavity, which itself may also require examination (see the Nose). Examination should also assess facial movement and sensation. The buccal and zygomatic branches of the facial nerve (CN VII) supply most of the musculature in this area. This is especially important when examining facial lacerations in this region (or blunt trauma to the side of the face) (Fig. 18.5).

Following trauma to the midface, examination must also include an assessment of midface mobility. This is discussed later in relation to midface injuries. Fractures in this area are commonly referred to as "Lefort" fractures, although pure Lefort fractures are not often seen today. Furthermore, other fractures often coexist. Although historically the aim of examination was to identify the 'level' of any fracture, today this is determined by CT imaging. Nevertheless the identification of midface mobility is important in the triage process, to anticipate complications, determine safety if transfer is required and in the planning of treatment. For the inexperienced, a simplified trauma "check list" can be useful. This list is applicable to all injuries between the eyebrows and upper teeth.

18.5.1 Examination of the Midface Following Trauma

- General features
  - ATLS/ABCs, notably progressive facial swelling, active bleeding, and cervical spine injuries
- Neurosurgical
  - GCS

  - CSF rhinorrhoea/otorrhoea (cranial fossa fractures).
  - Complications of CSF leaks (meningitis or aerocele)
- Ophthalmic
  - Visual acuity, signs of globe injury, pupil reaction to light
  - Enophthalmos/ocular dystopia
  - Diplopia
- Maxillofacial
  - Abnormal mobility of the midface
  - Posterior pharyngeal collapse
  - Anterior open bite
  - Apparent trismus—premature contacts in the molar region
  - Lengthening of the midface
  - Splitting of the palate
  - "Dishfaced" deformity/increased intercanthal distance
  - Crepitus

18.6 Investigating Symptoms and Signs

18.6.1 Laboratory Tests

A Full blood count with differential, Urea and Electrolytes, coagulation screen, group and save, and C-reactive protein/ESR usually required with severe symptoms of in any suspected infective, inflammatory, systemic or neoplastic (leukaemia, lymphoma) pathologies. Disorders such as Wegner's granulomatois or granulomatosis with polyangiitis may present within the hard palate or maxillary sinus. Clinical signs and a raised ANCA is highly suspicious of the disease. An ESR should also be taken if the patient is complaining of unusual or atypical features of pain. Giant cell arteritis can occasionally present as unilateral facial pain and headache.

18.6.2 Plain Films

Occipitomental views (OMs) are still used as an initial screening series for most presentations, unless the patient is significantly affected by their injury or disease. One or two OM projections (15° and 30°), together with careful clinical examination should be able to exclude most significant fractures. "Cracks" in the midface are not important clinically if they are firm. They do not need repair although patients should be advised not to blow their nose for 3 weeks. A lateral view of the face may also show displacement of the maxilla. It is also useful in the assessment of the frontal sinus (fluid levels, posterior wall fractures) and in visualising the pterygopalatine plates. This view is perhaps less used today as access to urgent CT has improved which provides far more information. Nevertheless if CTs are not available this is a useful view to inspect (Figs. 18.6, 18.7 and 18.8).

Fig. 18.6 Occipital mental view

Fig. 18.7 Paranasal cavities X-ray, lateral view. Sella turcica (arrowhead), frontal sinus (1), maxillary sinus (2), sphenoid sinus (3)

Fig. 18.8 Paranasal cavities X-ray, Caldwell's projection. Frontal sinus (1), maxillary⁻ sinus (2), inferior turbinate (3), nasal septum (4), ethmoid cells (5), petrous bones (6)

In cases of suspected sinusitis, mucosal thickening may be seen as an increased opacity, lining the sinus wall or hazy sinus contents. However plain films are generally insensitive. Considerable disease in the sinuses may go undiagnosed. Nevertheless, plain films may be used to screen for mucosal thickening and fluid levels although they have generally been supplanted by CT. Plain films cannot identify bone erosion and are insufficient to evaluate complications of sinusitis (Figs. 18.9 and 18.10).

Further specialist periapical and upper occlusal views are useful in the assessment of dentoalveolar fractures and dental related infections. The OPG (usually taken for lower jaw assessment) may also show low level LeFort I fractures, fractures of the zygomatic arch, and upper dentoalveolar fractures/dental injuries. The OPG often includes much of the upper jaw and is therefore another useful 'first line' investigation. It will identify most cysts and bony tumours in the upper jaw, although these may be obscured by the cervical spine and other artefacts. Patients with suspected midface fractures and large cysts/tumours etc. should undergo urgent CT scanning.

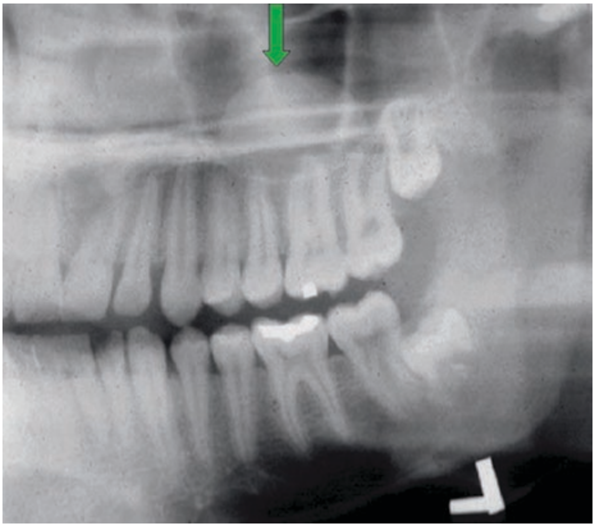

Fig. 18.9 Mucous retention phenomenon: detail from panoramic radiograph shows a smooth-outlined dome-shaped soft tissue density in left maxillary sinus (arrow)

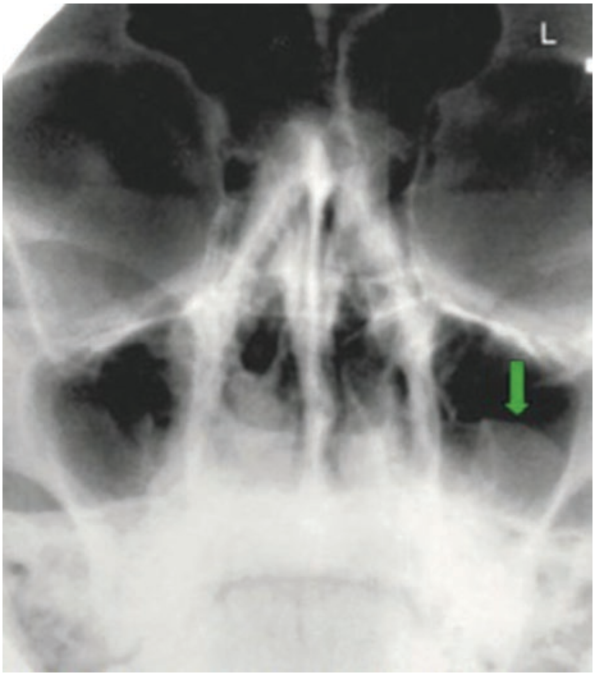

Fig. 18.10 Mucous retention phenomenon of maxillary sinus (arrow) shown using the occipitomental projection (Waters projection). This projection can be made using the cephalometric attachment available for use with panoramic systems

18.6.3 CT/MRI

Patients often present to the emergency department with a wide variety of traumatic, infectious, inflammatory and neoplastic conditions related to the upper jaws and nearby sites. Early concerns need to consider involvement of the airway, nasal cavity (resulting in major epistaxis), orbit and cranial base. Because of this, the role of

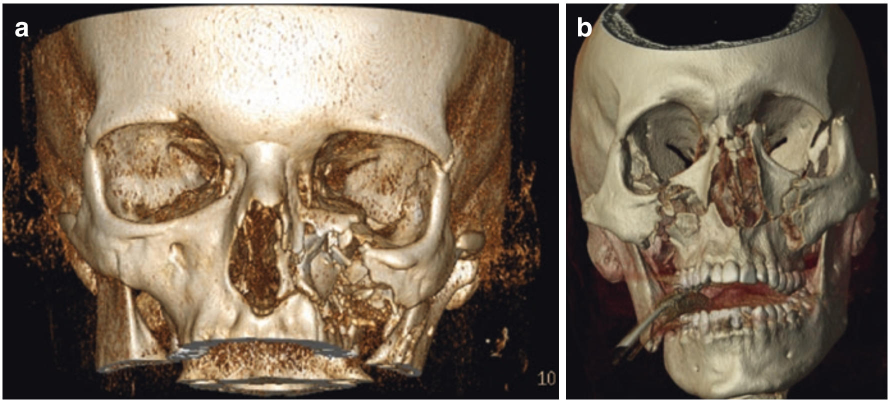

Fig. 18.11 (**a** and **b**) 3DCT offers excellent visualisation in trauma

CT has become almost routine in the emergency setting. CT is essential in the assessment of suspected sinus disease, large dental cysts, tumours and some spreading infections. Appearances are discussed later and elsewhere in this book. Sinonasal CT and MRI should be viewed in axial and coronal sections. Coronal views are useful for the most routine "screening" sinus examinations, as these also visualise the anterior skull base, orbit and intracranial structures. Axial images are helpful in assessing key sites such as the orbital apex, pterygopalatine fossa, infratemporal fossa, posterior choanae and nasopharynx. Sometimes, sagittal sections may be necessary to look at the inner table of the frontal sinus, frontal recess region, and cribriform plate and the anterior wall and floor of the middle cranial fossa (Fig. 18.11).

Oral cavity infections, tonsillitis and peritonsillar abscess, sialadenitis, parotiditis, periorbital and orbital cellulitis, infectious cervical lymphadenopathy and various neoplasms can all extend to involve, or be a consequence of midface pathology. Less common conditions that require rapid diagnosis and treatment include invasive fungal sinusitis, angioedema and deep neck abscess. Wegener granulomatosis should be suspected in destructive or infiltrative processes involving the head and neck region whose morphology mimics neoplasm but biopsies are non-specific or show a granulomatous process. A hallmark of fungal disease is its predictable involvement of vascular bundles, such as those passing through the sphenopalatine foramen or the infraorbital canal. These vascular pathways allow disease to develop on both sides of the bone, sometimes without obviously destroying it. In the context of trauma, although CT is undoubtedly more accurate than plain films, its true value is determining the presence of "deep" or occult injuries—those that may not be apparent on clinical examination. These include.

- Cervical spine injuries.
- Skull base fractures/intracranial air (CSF leaks).
- Skull base fractures around vascular foramina (notably carotid).
- Globe rupture/vitreous haemorrhage

- Orbital apex fractures/optic nerve compression
- Fractures of the pterygoid plates

Knowledge of these imaging findings is therefore essential to ensure an accurate diagnosis of these conditions, some of which are potentially life or sight-threatening conditions.

Computed tomography is commonly used to assess facial trauma. With the high definition of the current scanners, even small fractures of the facial skeleton can now be visualised. 3D reformatting makes injury recognition at a glance so much easier. This is especially important in naso-orbitoethmoid fractures, zygomatico-maxillary fractures and LeFort fractures, where identification of any split palate is essential. Le Fort fractures by definition involve disruption of the pterygoid plates of their separation from the posterior maxilla. Any combination of Le Fort I, II, and III patterns can occur. Disimpaction and manipulation of midface or nasal fractures, a common procedure, can potentially manipulate deep, mobile bone fragments around the skull base and optic nerve. This can result in major complications, notably CSF leaks and visual impairment. CT is therefore important in the evaluation of the fracture patterns. Once these fractures are confirmed (or excluded) the risks of manipulation can be recognised.

CT is especially useful if patients are neurologically impaired, very swollen, or already intubated for whatever reason and clinical examination is difficult and unreliable. CT helps overcome some of these diagnostic limitations. Fungal sinusitis has been reported to be increasingly common in some parts of the world. Acute invasive fungal sinusitis, chronic invasive fungal sinusitis, and chronic granulomatous invasive fungal sinusitis comprise an invasive group, whereas allergic fungal sinusitis and fungus ball (fungal mycetoma) are noninvasive. These are distinguished by both clinical and radiologic features. Prompt CT diagnosis is essential to avoid a protracted or fatal outcome. When considering functional endoscopic sinus surgery in the management of recurrent and refractory sinusitis, preoperative computed tomography can identify anatomic variants that predispose to surgical complications. The mnemonic "CLOSE" is helpful in remembering key sites (Cribriform plate, Lamina papyracea, Onodi cell, Sphenoid sinus pneumatization, and (anterior) Ethmoidal artery).

Evaluation of paediatric patients in the emergency setting is often complicated by a limited history and poor cooperation, restricting examination. Clinical findings often suggest multiple diseases. Imaging therefore plays a critical role in diagnosis. Radiography, ultrasonography, and contrast material–enhanced computed tomography are all useful modalities in the initial examination. In complex cases, magnetic resonance imaging may offer additional detail with respect to the extent of disease. Whilst CT is usually the first-line imaging modality in the emergency setting, magnetic resonance imaging plays an important secondary role.

MRI is of value mostly in the assessment of the soft tissues. In the acute trauma setting it is not commonly used, except in the assessment of cervical spine injuries (ligament or spinal cord damage), although this is often undertaken later. MRI is commonly used in the assessment of patients presenting with facial pain, trigeminal neuropathy and facial palsy. Although uncommon, skull base tumours and demyelinating conditions can present with pain or other neurological symptoms and therefore must be excluded before the patient is diagnosed with 'atypical' facial pain or Bell's palsy. Cranial nerve deficits have many causes and MRI to visualise the entire pathway of the nerve is essential.

18.6.4 Ultrasound

The use of ultrasonography has became popular in recent years owing to radiation dose and economic issues. However routine use in the emergency department for midface disease or injuries is rare. Nevertheless US has been reported to visualise fine detail of the surface structure without the need for ionizing radiation. Common uses include examination of bone and superficial soft tissues, detection of salivary gland lesions, temporomandibular joint imaging, assessment of fractures and vascular lesions, lymph node examination, measurement of the thickness of muscles and visualisation of vessels of the neck. It also has the potential to be used in the evaluation of odontogenic cysts, dental periapical lesions, periodontal pocket depth and determination of gingival thickness in dental implantology. The main drawbacks include limited penetration into bone and gas filled structures and less spatial resolution in the deeper tissues.

US has been reported to be useful in midface fractures, notably for the visualisation of the anterior wall of the frontal and maxillary sinuses and zygomatic arch. However, its use is still limited and doesn't necessarily help the surgeon plan repair. It is therefore not a substitute for X-ray imaging. Ultrasound has also been found to be of value in the diagnosis and treatment of odontogenic facial abscesses. It is an effective tool in both confirming abscess formation in the superficial facial spaces and detecting the stage of infection. US is able to identify microbubbles of gas in supurative sialadenitis along with adjacent reactive nodes. It can also help differentiate soft tissue swelling from an abscess and distinguish solid from fluid masses. Colour Doppler may show hyperemia adjacent to the abscess cavity and absence of flow within it. Although this may help in the assessment of soft tissue swelling, it provides less information than and MRI or CT.