Anatomical Variations in Clinical Dentistry

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Editors

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Preface

Anatomical variations are encountered on a daily basis by those specialists entering the oral cavity (e.g., dentists and oral surgeons) and adjacent regions. Therefore, for optimal daily clinical practice, both trainees and professionals in these fields and others (e.g., endodontists, periodontists, implantologists, anatomists, maxillofacial surgeons, otolaryngologists, dental students, and dental hygienists) should be aware of the most common variants found in the oral cavity. *Anatomical Variations in Clinical Dentistry* seeks to provide a go-to reference on this topic. The book begins by introducing the reader to anatomical variations from the point of view of different clinical practitioners—oral and maxillofacial surgeons, periodontists, and endodontists. The newest anatomical knowledge and variations are then presented in turn for the mandible, maxillary sinus, hard palate, floor of the mouth, lips, temporomandibular joint, and teeth. In each chapter, clinical annotations are included in order to enhance the understanding of the relationships between surgery and anatomy. The internationally renowned authors of the text have been carefully selected for their expertise.

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Part I

Anatomical Variations from the Point of view of Clinical Practitioners

Anatomical Variations Relevant to Oral and Maxillofacial Surgeons

1

Jingo Kusukawa

Anatomy provides the foundation of surgery and is the most basic and essential science in surgery. It is indispensable not only for meeting diagnostic challenges but also for developing surgical procedures. Therefore, anatomy is a basic requirement for all surgical specialties.

Oral and maxillofacial surgery specializes in treating pathological conditions and disorders, injuries, defects, deformities, and malformations in the hard and soft tissues of the oral cavity, jaws, face, and adjacent organs. Therefore, oral and maxillofacial surgeons require specific skills that also necessitate detailed knowledge of the relationships among the anatomical structures encountered during surgical operations in this area. Insufficient anatomical knowledge can result in serious complications and poor cosmetic or functional postoperative results. Clinical anatomy, giving consideration to practical surgery, is crucial for enhancing diagnostic efficiency and performing a safe and effective operation. In addition to fundamental knowledge of the clinical anatomy of the oral and maxillofacial region, we should deepen our understanding of anatomical changes during aging and anatomical variations among individuals.

Morphological changes caused by disuse atrophy of alveolar and jaw bones following tooth loss handicap the surgeon's search for anatomical landmarks such as the piriform aperture and anterior nasal spine, incisive papilla (incisive canal), hamular notch, and neural foramina. Decrease of the alveolar ridge height increases the risk for injury to nerves and blood vessels emerging from neural foramina including the greater palatine foramen (Fig. 1.1), the infraorbital foramen, and the mental foramen. Narrowing of the alveolar ridge increases the risk that the surgeon's scalpel blade leaves the alveolar crest and cuts deeply inside.

Furthermore, anatomical variations complicate the situation of the operation. Such variations are potential risk factors in oral and maxillofacial surgery. In

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Fig. 1.1 Greater palatine foramen (arrow), nerve, and artery

particular, variations of nerves and blood vessels entail the risk of serious complications. Uncontrollable bleeding from blood vessel injuries can be life-threatening. Permanent nerve injury has a serious negative effect on the patient's quality of life. To avoid such complications, surgeons should be familiar with anatomical variations as well as preventive care.

Third molar surgery remains the commonest procedure carried out by general dentists and oral surgeons. One of the main concerns in third molar surgery is inferior alveolar nerve (IAN) injury. The incidence of permanent IAN injury ranges from 0.35% to 8.4% (Sarikov and Juodzbalys 2014). Apart from third molar surgery, the IAN is at risk of trauma during oral surgery operations such as jaw cyst surgery, or implant surgery. The IAN enters the mandible from the mandibular foramen, which is inside the mandibular ramus, passes through the mandibular canal, leaves from the mental foramen outside the mandibular body, and is distributed over the lower lip and mental region as the mental nerve (MN). To avoid unnecessary complications, we should recognize that there are many variations in the pathway of the IAN and MN. It is well known that the positional relationship between the third molar and mandibular canal corresponds to the incidence of IAN injury. In addition, the prevalence of accessory mental foramina ranges from 2.0% to 13.0% (Iwanaga et al. 2015). Such accessory foramina in the vicinity of the mental foramen are a potential risk for paresthesia of the lower lip and mental region.

Lingual nerve (LN) paralysis is serious complication in oral surgery. As the LN runs along the lingual aspect of the mandible and reaches the tongue through the floor of the mouth, it can be injured by oral surgery operations including third molar surgery, jaw resection, grafting of the alveolar crest, salivary gland surgery,

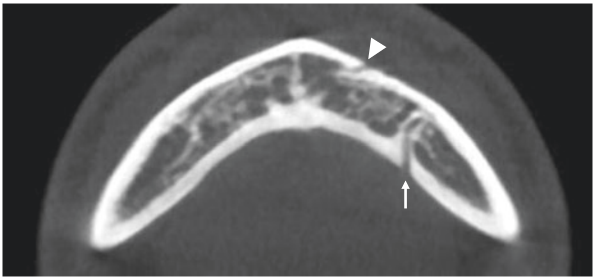

Fig. 1.2 Mandibular lingual canal in the canine-premolar region (arrow). Additional buccal bony canal in the incisal region (arrowhead)

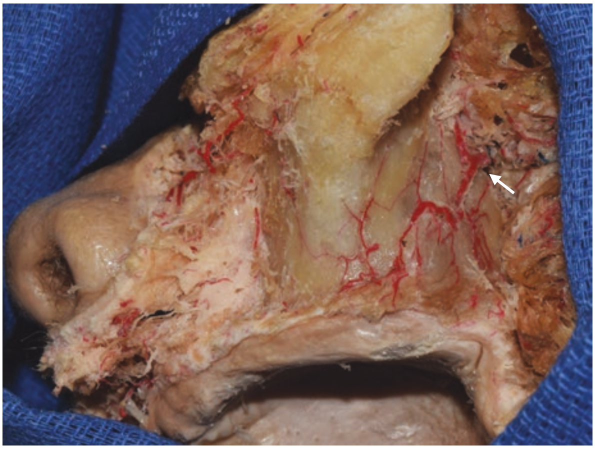

Fig. 1.3 Left posterior superior alveolar artery (arrow)

placement of implants, and tumor excision. The incidence of such complications ranges from 0.04% to 22% (Dias et al. 2015). Although nerve injury is a rare complication, its implications can be significant for the patient.

The sublingual artery (SLA) is a major branch of the lingual artery, branches of which supply the floor of the mouth and occasionally enter the mandible through lingual bony canals (Tepper et al. 2001; Sahman et al. 2014) (Fig. 1.2). During intraosseous surgery of the mandible such as implant placement, the lingual bony canals present a risk for SLA injury, resulting in the development of a large hematoma in the floor of the mouth, which can lead to life-threatening airway obstruction. The posterior superior alveolar artery (PSAA) (Fig. 1.3), one of the terminal branches of maxillary artery, supplies blood to the lateral wall of the maxillary sinus and the sinus floor membrane (Maridati et al. 2014). Injury to the PSAA in sinus-related surgery represented by sinus floor augmentation can cause massive perioperative bleeding (Güncü et al. 2011). To avoid traumatizing these blood vessels, locating their exact position prior to the operation is mandatory.

To perform a safe and reliable surgical operation without complications, surgeons need to be aware of the anatomical variations and detect them precisely prior to surgery, in addition to understanding normal structures. Preoperative detection of anatomical variations of soft tissues is limited. Although angiography, angiographic CT and magnetic resonance angiography (MRA) are the main modalities for detecting the vascular distribution and its variations, they are highly invasive and costly. Additionally it is extremely difficult to detect the nerves in the soft tissue. Operation under direct vision is the most reliable method for detecting and handling them. Anatomical landmarks are also useful for ensuring that the surgical operation proceeds safely and smoothly.

On the other hand, radiographic imaging can identify anatomical variations in bone. The orthopantomogram (OPG) has classically been used to evaluate the jaws, including the maxillary sinus, the mandibular canal and the mental foramen, and their relationships to the teeth. However, OPG does not permit three-dimensional (3D) assessment of their position or visualization of the lingual canals. Multidetector CT and cone beam CT (CBCT) permit finely detailed visualization of the osseous architecture with high resolution and accuracy. Multiplanar reconstruction (MPR) imaging provides surgeons with more detailed anatomical information for recreating two-dimensional (2D) images in optionally different planes and 3D volumetric views. MPR imaging, as provided by MDCT/CBCT, is undoubtedly increasing diagnostic efficiency and surgical accuracy, but it is a novelty for dentists and oral and maxillofacial surgeons. In addition to the development of high-resolution imaging equipment, digital technology has been integrated into surgical planning and procedures. In oral and maxillofacial surgery, computer-aided design/computer-aided manufacturing (CAD/CAM) techniques have been developed to build surgical guides and mock-up 3D full-size models in an attempt to improve the precision of surgical operations such as implant placement, tumor resection, and reconstruction of the jaw. In the near future, robotic surgery and artificial intelligence will be applied to clinical oral and maxillofacial surgery. Such innovations in oral and maxillofacial surgery will improve the safety and accuracy of operations drastically. Whatever the progress in diagnostic and surgical technology, we should remember that anatomy is fundamental and essential for surgeons to secure and make advances in oral and maxillofacial surgery.

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Anatomical Variations from the Point of View of the Periodontist

2

Daniel E. Shin

2.1 Introduction

Periodontal surgery encompasses a wide range of surgical therapies that are designed to restore and regenerate the natural form and function to lost and damaged structures of the teeth. Common types of periodontal surgical therapies include, but are not limited to, open flap debridement, osseous resective surgery, guided tissue regeneration (GTR), and soft tissue augmentation. It is important for a periodontist to have sound clinical judgment and proficient skills to perform the aforementioned surgical procedures, but it is equally important for the periodontist to have a keen anatomical mind with the means to appreciate the subtle nuances or the overt and pronounced anatomical variations that lie in the vicinity of the periodontal surgical field. Furthermore, it is important for the periodontist to anticipate these anatomical variations and the role they may play in determining the scope of the planned surgical procedure. Thus, in order to safely and properly execute the surgical procedure, the periodontist must have a strong understanding of the precise location of anatomical structures but also be aware of variations with respect to size, shape, and location of vital oral anatomical structures and landmarks. The focus of this chapter is to highlight common variations in anatomical oral structures, which are regularly encountered in periodontal surgery and implant surgery. The reader is referred to subsequent chapters in this textbook for a more in-depth description of these anatomical structures and landmarks.

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2.2 Common Anatomical Variations Relevant to Periodontal Surgery

The maxillary palate is an area which requires caution and care due to variation of the precise location of the greater palatine neurovascular bundle and its associated foramen. The extent and depth of the surgical incision and the type of flap elevation are dictated by the location of the greater palatine foramen and the position of the greater palatine neurovascular bundle.

2.2.1 Greater Palatine Foramen and Greater Palatine Neurovascular Bundle

Although the incidence is low, any iatrogenic injury of either the greater palatine foramen or its neurovascular structure may result in bleeding and/or paresthesia (Harris et al. 2005). Thus, the surgeon must have a clear understanding of the precise location and possible anatomical variations associated with these aforementioned structures. The greater palatine neurovascular bundle descends through the greater palatine canal and emerges out of an opening in the hard palate known as the greater palatine foramen. Generally, the greater palatine foramen is approximately 3–4 mm anterior to the posterior border of the hard palate and 15 mm from the palatal midline. From there, the greater palatine neurovascular bundle courses anteriorly in a groove that is formed at the junction of the palatine and alveolar processes.

2.2.1.1 Variations in the Anatomic Configuration of the Greater Palatine Foramen

A clear understanding of the location and anatomy of the greater palatine foramen is needed prior to performing any type of periodontal surgery in the maxillary palate. However, the precise location and the position of the greater palatine foramen can vary among individuals. A systematic review and meta-analysis identified five possible positions for the greater palatine foramen: (1) anterior to the mesial surface of the second molar, (2) in between the mesial surface and the distal surface of the second molar, (3) at the interproximal level between the second and third molars, (4) in between the mesial surface and distal surface of the third molar, and (5) distal to the third molar (Tomaszewska et al. 2014). Out of these five possible locations, the greater palatine foramen was most often located in between the mesial surface and the distal surface of the third molar—on average, this was seen in two-thirds to three-quarters of all patients, both in Europe and worldwide. On the other hand, in another study that examined the location of the greater palatine foramen from skull dissections, it was found that the main location of the greater palatine foramen was directly palatal to the second molar (Klosek and Rungruang 2009). In another skull dissection study, Fu et al. (2011) found that the most common location of the greater palatine foramen was between the second and third molar teeth. Such uncertainty in the precise anatomical location of the greater palatine foramen makes the maxillary posterior palatal region a challenge to perform a wide variety of anesthetic, dental, and surgical procedures.

2.2.1.2 Variations in the Anatomic Configuration of the Greater Palatine Neurovascular Bundle

After exiting the greater palatine foramen, the greater palatine neurovascular bundle courses through a groove that is formed at the junction of the palatine and alveolar processes. For a periodontist, it is important to know the location of the greater palatine neurovascular bundle because dissection of the palatal mucosa can be dictated by the shape of the palatal vault. In general, the location of the greater palatine bundle from the CEJ is correlated to the height of the palatal vault: for a low palatal vault, the average distance between the greater palatine artery and the CEJs of maxillary molar teeth is 7 mm; for an average palatal vault, the mean distance is 12 mm; and for a high U-shaped palatal vault, the average distance is 17 mm (Reiser et al. 1996).

For a periodontist, the greater palatine neurovascular bundle has two important clinical significances. First, when performing palatal surgery, vertical incisions in the posterior palate should be avoided to eliminate the risk of iatrogenically injuring the greater palatine neurovascular bundle. Second, when harvesting autogenous subepithelial connective tissue grafts, the clinician must be aware that harvesting the palatal graft tissue more than 7 mm from the CEJs of maxillary molars in a shallow vault, 12 mm in an average vault, and 17 mm in a high palatal vault may lead to undesirable complications, such as hemorrhaging or nerve damage.

2.2.2 Anatomy and Variations of the Maxillary Sinus

Structurally, when one thinks of the maxillary sinus, the image of a house comes to mind. Externally, the antrum (cavity) of the maxillary sinus is surrounded by six bony walls on the anterior, medial, posterior, lateral, superior, and inferior sides. Internally, the walls of the aforementioned sinuses are lined by a mucoperiosteal lining known as the Schneiderian membrane. Understanding the anatomy and the relevance of these bony walls and the mucoperiosteal lining is crucial for the periodontist due to the close association of blood vessels and nerves to the sinus walls.

The anterior wall of the maxillary sinus contains the infraorbital nerve and a branch of the infraorbital artery known as the anterior superior alveolar artery. The anterior superior alveolar artery feeds blood to the anterior portion of the mucous membrane of the maxillary sinus and to the anterior teeth (from incisor to canine) and its surrounding periodontium. When preparing the osteotomy (access) via a lateral approach, the access preparation line should be made at a safe distance from the anterior wall to avoid disrupting branches of the infraorbital nerve and blood vessels to the maxillary anterior teeth.

The medial wall of the sinus separates the maxillary sinus from the neighboring nasal cavity. The superior portion of the medial wall of the sinus contains the ostium, which is an opening that drains mucous from the maxillary sinus into the middle meatus of the nasal cavity. It is vital to keep this ostium patent since the health of the sinus is dependent on proper drainage of both mucous and bacteria out of the maxillary sinus. As such, when performing a sinus lift procedure, the periodontist must be careful to avoid overfilling the sinus with graft material which could potentially occlude the ostium. If this were to occur, sinusitis may occur.