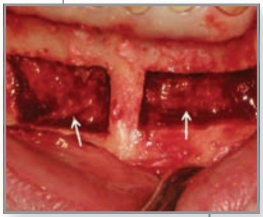

Revised Maxillofacial Anatomy: The Mandibular Symphysis in 3D

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Abstract: *Placement of dental implants in the anterior mandible is considered by many clinicians to be a relatively low risk procedure. However, hemorrhagic episodes following implant placement in the mandibular symphysis are regularly reported and can have serious consequences. The use of high resolution focused cone beam scanners has given us the ability to visualize the intricate neurovascular network of the intraforaminal region without distortion and in greater detail. Knowledge of the arterial supply, and navigated implant placement in the mandibular symphysis, can help to avoid these potentially life-threatening emergencies.* TITANIUM 2009 1(2): 0-0

Key words: *incisive canal, lingual artery, mylohyoid artery, submental artery, superior genial foramen.*

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INTRODUCTION

Preoperative assessment of bone density and volume is a critical component of dental implant surgery. For most of the history of this discipline, periapical or panaoramic X-rays have been used to evaluate implant sites. Limitations of these radiographic modalities are distortion, magnification, and a missing third dimension of bone volume. The introduction of computed axial tomography (CT) revolutionized our ability to virtually dissect maxillofacial structures and to determine osseous architecture without distortion.[1] However, CT imaging has 3 major drawbacks. First, is the relatively high radiation dose during the scanning procedure.[2] Second, is the high degree of background scatter around metallic restorations and implants.[3]Third, is the significant burnout of medullary bone that is directly proportional to the radiation dose.[4]These parameters often obscure fine osseous structures and eliminate soft tissue profile. Our lack of appreciation for the complex anatomy of the mandibular symphysis occasionally leads to unintended consequences or even life-threatening emergencies. There are many case reports in the literature describing hemorrhagic episodes following surgical implant placement that resulted in near-fatal airway obstruction.[6-11] Some authors have even suggested that a CT scan should be routinely performed prior to the placement of implants in the intraforaminal region.

The more recent introduction of low radiation focused cone beam scanners has enabled us to view osseous architecture in a highly detailed format, without burnout, and with greater contrast.[12] In addition, the ability to create tomographic slices down to .08 mm gives us a true volumetric representation of the arch. Fine osseous architecture can now be visualized without data loss. For the first time, anatomical structures that have been anecdotally reported in the literature may now be routinely examined.

The Incisive Canal

For decades, the intraforaminal region of the mandibular arch has been called "the zone of safety". This term has been used because of the relative absence of sensory deficit to the lip and chin after placement of dental implants as compared to the region posterior to the mental foramen. It is now clear, however, that there are additional considerations based on the presence of critical structures in this area.

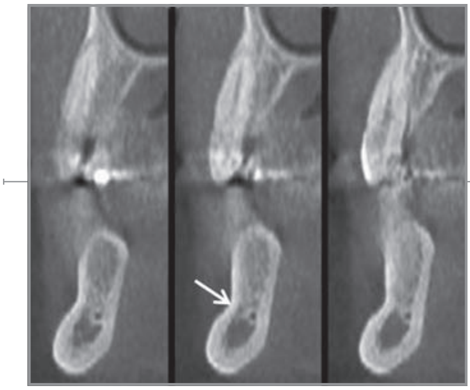
Figure 1: Cross-sectionals, anterior to the mental foramen, demonstrating the course of the incisive canal.

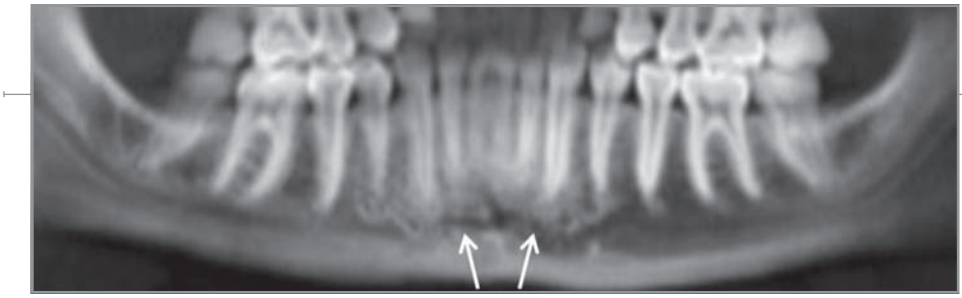
Figure 2: Panoramic X-ray view of incisive canal, demonstrating contralateral anastamosis.

The literature has reported that there is a loop of the mental foramen that extends 5-7 mm anteriorly[13] and it may often appear on panoramic images. In some cadaver studies, however, it has been reported that this loop exists in only a few specimens examined and that its importance is marginalized.[14] Digital volumetric tomography of our patients indicates that not only is there an anterior extension of the mental foramen in 100% of these scans, but that it is not a loop. It is a continuation of the inferior alveolar nerve known as the incisive branch (Fig. 1).

When we examine the body of the mandible, we find that ⅔ of the inferior alveolar nerve (IAN) exits at the mental foramen. This is the neurovascular supply to the lip and chin on that side. One

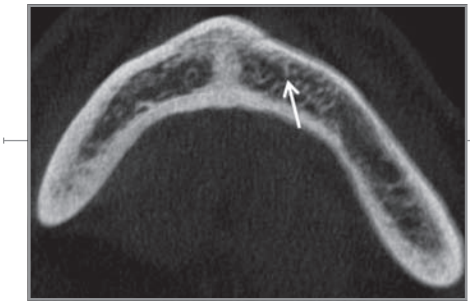
Figure 3: Bucco-lingual position of incisive canal approaching the midline.

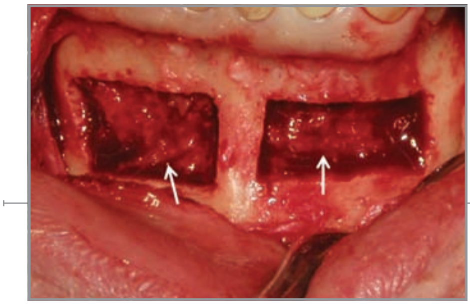
Figure 4: Harvesting of symphysis block grafts exposing the incisive canal.

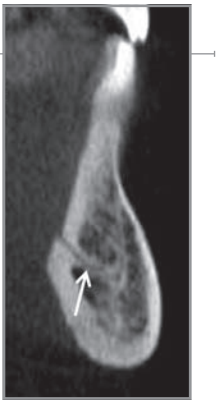

Figure 5: Lingual artery anastamosing with the incisive canal at mid-symphysis.

Figure 6: Consequence of severe bleeding subsequent to implant placement in the mandibular symphysis.

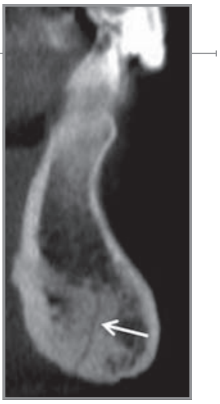

Figure 7: Submental artery at mid-symphysis, anastamosing with the incisive canal.

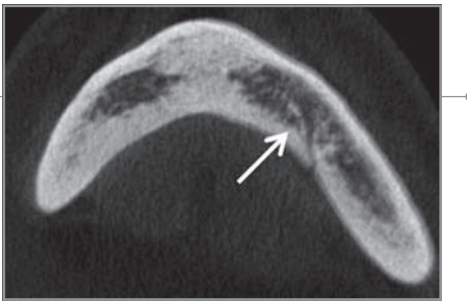

Figure 8: Antero-posterior course of mylohyoid artery.

third of the IAN continues through the incisive canal and anastamoses with the contralateral side (Fig. 2).

This incisive branch is the neurovascular supply to all of the anterior teeth and the chin closer to the midline.[15] The incisive nerve begins on the facial side of the body of the mandible and tends to move towards the lingual of the mandible at mid-symphysis when seen in cross section (Fig. 3).

Clinicians performing autogenous block graft procedures often prefer symphyseal bone for the shape and volume of the graft needed.[16] Following removal of the bone block, some surgeons may harvest the medullary bone and hemopoetic tissue available (Fig. 4). In doing so, they may inadvertently resect the incisive nerve and blood supply. After healing, patients often complain of an altered sensation in the affected anterior teeth. This iatrogenic result can be avoided by resisting the temptation to aggressively manipulate the medullary bone after harvesting the graft.

There are also reports in the literature of dysesthesia following placement of dental implants within the region 10 mm anterior to the mental foramen.[17] This may be caused by injury to the incisive nerve in the cuspid position. The patient will not exhibit parasthesia of the lip or chin because the injury is anterior to the sensory division to those areas. However, Wallerian degeneration of the nerve may result in pain or a burning sensation following transection or compression.[18] This type of injury can be avoided by pre-surgical evaluation of the position of this nerve on cross section.

One study, that compared post operative neuropraxia following block harvesting of grafts from the ramus versus the symphysis, demonstrated that after 18 months, more than 50% of the patients still had altered sensation with symphysis donor sites while there were no symptoms with the ramus group.[19]

Lingual Artery

In addition to the incisive neurovascular bundle, there are additional vascular structures that anastamose with this branch. The genial tubercle at mid-symphysis is the attachment point for the genioglossus muscle.[20] It also houses the lingual foramen through which the lingual artery courses.[21] This artery is approximately 1-2 mm in diameter and can be seen to anastamose with the incisive canal in cross sectional views[22] (Fig. 5).

Drilling procedures for placement of dental implants can potentially resect these blood vessels. If this occurs, the artery may prolapse back into the floor of the mouth.[23] The sublingual space will fill with arterial blood, raising the tongue until the airway is compromised.[24] Immediate emergency care is indicated with the possibility of tracheostomy until blood flow is controlled (Fig. 6). The placement of implants at mid-symphysis should be carried out with knowledge of the position of the lingual and submental arteries as well as ridge trajectory. If there is insufficient bone above these vascular components, placement of implants at mid-symphysis should be avoided.

In one study, computed tomograms of 70 patients were examined for visible vascular canals in the mandible as well as for their localization, incidence, diameter, and content. All patients examined showed at least 1 lingual perforating bone canal in the mandible. In a cadaver study, the number of intraforaminal lingual vascular canals ranged from 1 to 4. At least 1 lingual vascular canal was found in 80% of the mandibles studied.[25] Since such vascular canals are encountered regularly, the authors recommend a routine CT or CBCT (focused cone beam computed axial tomography) examination prior to implant surgery to help avoid severe bleeding complications during the placement of implants in this region.

Submental Artery

More variable than the lingual artery, branches of the submental artery are also seen to anatamose with the incisive canal at, or adjacent to, the symphyseal midline (Fig. 7). The sub-mental artery is a branch of the facial artery and is considered to be the main arterial blood supply to the floor of the mouth and mandibular lingual gingiva. This vessel runs medial to the mandible and may insert into the mandibular symphysis at the inferior border. Transection of the submental artery requires deep dissection in the floor of the mouth and ligation of the facial artery. The submental artery also supplies the submandibular lymph nodes, submandibular salivary gland, mylohyoid and digastric muscles, and the skin of the chin. The submental vein drains the tissues of the chin as well as the submandibular region.[26]

Mylohyoid Artery

Branches of the facial artery run anteromedially below the mandible and superficial to the mylohyoid muscle. They give off some perforating branches to the overlying platysma and the mylohyoid branch to the underlying mylohyoid muscle during its course. The terminal branches continue toward the midline, crossing the anterior belly of the digastric muscle either superficially or deep, and end at the mental region in general. Some perforating arteries from the terminal branches supply the anterior belly of the digastric muscle. The mylohyoid artery tends to course from the lingual cortex at the bicuspid region and finally anatamosing with the incisive canal at the cuspid position (Figs. 8-10).

Superior Genial Foramen

All radiographic imaging techniques demonstrate the mental foramen. Occasionally, periapical or panoramic films may indicate an anterior extension to the IAN. However, structures smaller than 3 mm may show up as artifact or be indistinguishable from the surrounding bone. There have been anecdotal reports of accessory foramina anterior to the mental foramen, varying in number, size, and location.[27] Utilizing focused cone beam imaging in the 6" field of view to produce the most favorable voxel size (3-dimensional pixel) and the lowest axial slice thickness (.08 mm), these accessory foramina can be clearly discerned. The authors have found that, in approximately 80% of scans, additional anterior foramina can be located and their anastamoses with the incisive canal traced. Some of these foramina can have a diameter of up to 2 mm, indicating a substantial neurovascular component exiting to supply the chin (Figs. 11, 12).

Reports of substantial bleeding in the symphysis after raising flaps may be attributable to these larger vessels.[28] These bleeding points have previously been described as "nutrient canals", indicating that they had no sensory component. Following block graft harvesting, parasthesia of the midline chin area has been reported and may be the result of transecting these anterior neurovascular components.[29] Injury to these vessels can be avoided by limiting the apical extension of flaps during implant placement and harvesting block grafts closer to the midline.

Figure 9: Anastamosis of mylohyoid artery with the incisive canal.

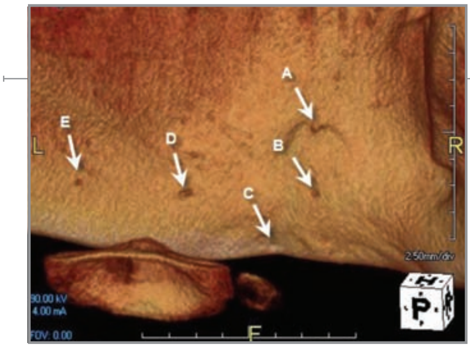

Figure 10: Multiple perforating vessels on the lingual surface of the anterior mandible. (A: lingual artery, B: sublingual artery, C: submental artery, D: mylohyoid artery, E: secondary mylohyoid artery).

Figure 11: Cross sectional of superior genial foramen at the cuspid position.

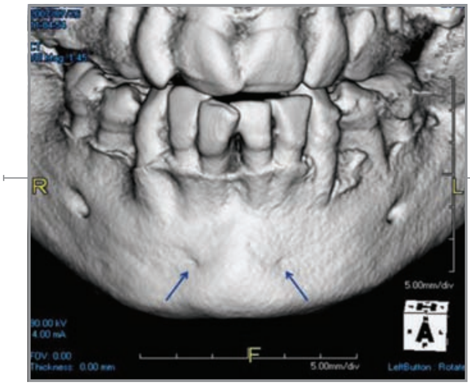

Figure 12: Reconstructed 3D image showing positions and relative sizes of the superior genial and mental foramena.

Figure 13: Distal bifurcated branch of the mental nerve.

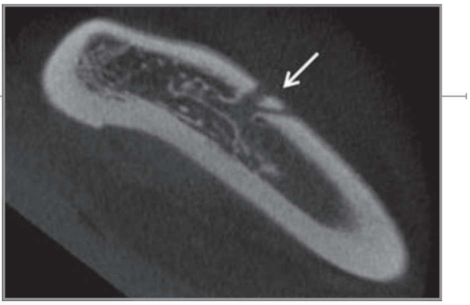

Figure 14: Axial tomography tracing the path of a bifurcated mental nerve.

Figure 15: Cross sectional tomograph demonstrating severe facial resorption.

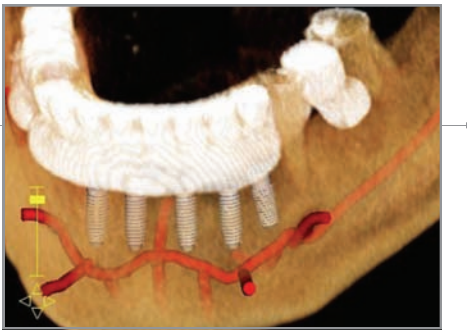

Figure 16: Virtual implant placement that bypasses critical structures (Easy Guide, Keystone USA).

Bifurcated Mental Foramen

Cases of double or bifurcated mental foramina are described in the literature, adding to the variability of the anatomy in this area (Figs. 13, 14).[30] The secondary, smaller foramen may be viewed as artifact on a periapical or panaoramic film. This neurovascular component may be inadvertently injured or transected during surgery, leading to parathesia of the lip and chin on that side.

Orientation of Ridge Position

Another advantage of focused cone beam imaging is the ability to create virtual study models. In addition to measuring the cross-sectional volume of the implant site, we can now measure the trajectory of the planned implant relative to the opposing dentition.[31] Focused cone beam imaging has recently been taken to a new level with the report of navigated insertion of implants using software originally developed for spinal surgery.[32] When a radio-opaque model of the final prosthesis is included in the scan, the position and trajectory of the implant can be planned for optimal emergence and biomechanics, taking into account the available bone and anatomic structures. In this way, implant dentistry becomes a more prosthetically driven discipline. The symphysis tends to resorb in a lingual direction, altering the trajectory of the symphysis to a pronounced lingual angulation (Fig. 9). In an attempt to create a more ideal emergence profile, surgeons often place implants with a more facial inclination. The available bone height may also be overestimated when looking at a panoramic X-ray view due to this lingual angulation. The osteotomy path may prematurely come in contact with the lingual plate, and perforation into the floor of the mouth may occur. This may damage sublingual blood vessels, resulting in a significant bleeding episode.[33]

Bone Density

Pre-operative evaluation of bone density is best accomplished with computerized tomography. Each pixel of an image has a CT number known as a Hounsfield unit. The higher the Hounsfield units, the greater the density of bone. In general, the denser the trabecular pattern, the greater chance of initial implant stability and consequently implant osseointegration. The symphysis is usually composed of D1 or D2 bone (Misch Classification) which has been correlated by Misch and Kirkos to measure 850 to greater than 1,250 Hounsfield units. Misch also reports failed sites in the mandible have higher than usual Hounsfield units.[34] This may be a result of denser cortical bone overheating during osteotomy preparation and a lack of vascularity at the site.

Navigated Surgery

Implant interactive software (i.e. Simplant, Materialise and Easy Guide, Keystone) has been developed that allows us to trace the neurovascular components of the intraforaminal region. Through the use of a radiographic prosthetic scan appliance, we can determine the ideal prosthetic positioning of our final reconstruction. Virtual implants can be visualized within the existing bone volume and, utilizing a passive navigation device, implants can be placed in positions that avoid damage to these critical neurovascular structures (Fig. 16).

CONCLUSIONS

The utilization of 12-, 14-, and 16-bit focused cone beam volumetric scanners gives us unparalleled imaging of fine structures in the oral and maxillofacial region.

The knowledge of intricate anatomy and our ability to avoid iatrogenic damage to critical structures in the mandibular symphysis will enhance patient care and safety. It will allow surgeons to preplan ideal implant placement and to make critical decisions prior to surgery. This enhancement to our understanding of maxillofacial anatomy will also enable us to move closer to fulfilling the concept of minimally invasive surgery as well as achieving more ideal patient outcomes.

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