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.

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

**INTRODUCTION**

Reoperative assessment of bone density and volume is a critical component of dental implant surgery. For most of the history of this discipline, periapical or panoramic X rays have been used to evaluate implant sites. Limitations of these radiographic modalities include distortion, magnification, and a missing third dimension of bone volume. The introduction of computed tomography (CT) revolutionized our ability to virtually dissect maxillofacial structures and to determine osseous architecture without distortion. However, CT imaging has 3 major drawbacks. First is the relatively high radiation dose used during the scanning procedure. Second is the high degree of background scatter around metallic restorations and implants. Third is the significant burnout of medullary bone that is directly proportional to the radiation dose. These parameters often obscure fine osseous structures and eliminate the 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. Many case reports in the literature describe hemorrhagic episodes following surgical implant placement that resulted in near-fatal airway obstruction. Some authors have even suggested that a CT scan should be performed routinely before placement of implants in the intraforaminal region.

The 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. 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, anatomic 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 with the region posterior to the mental foramen. It is now clear, however, that additional considerations are based on the presence of critical structures in this area.

The literature has reported that a loop of the mental foramen extends 5–7 mm anteriorly, 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 its importance is marginalized. 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 (Figure 1).

When we examine the body of the mandible, we find that two-thirds 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-third of the IAN continues through the incisive canal and anastomoses with the contralateral side (Figure 2).

This incisive branch is the neurovascular supply to all anterior teeth and the chin closer to the midline. The incisive nerve begins on the facial side of the body of the mandible and tends to move toward the lingual of the mandible at midsymphyssis when seen in cross section (Figure 3).

Clinicians performing autogenous block graft procedures often prefer symphyseal
bone for the shape and volume of the graft needed.\textsuperscript{16} Following removal of the bone block, some surgeons may harvest the medullary bone and available hematopoietic tissue (Figure 4). In doing so, they may inadvertently resect the incisive nerve and blood supply. After healing, patients often complain of altered sensation in the affected anterior teeth. This iatrogenic result can be avoided by resisting the temptation for aggressive manipulation of medullary bone after harvesting of the graft.

Reports in the literature describe dysesthesia following placement of dental implants within the region 10 mm anterior to the mental foramen.\textsuperscript{17} This may be caused by injury to the incisive nerve in the cuspid position. The patient will not exhibit paresthesia of the lip or chin because the injury is anterior to the sensory division of those areas. However, Wallerian degeneration of the nerve may result in pain or a burning sensation following transection or compression.\textsuperscript{18} This type of injury can be avoided by presurgical evaluation of the position of this nerve on cross section.

One study that compared postoperative neuropraxia following block harvesting of grafts from the ramus vs the symphysis demonstrated that after 18 months, more than 50% of patients still had altered sensation with symphysis donor sites, but no symptoms were noted within the ramus group.\textsuperscript{19}

**Lingual Artery**

In addition to the incisive neurovascular bundle, other vascular structures anastomose with this branch. The genial tubercle at midsymphysis is the attachment point for the genioglossus muscle.\textsuperscript{20} It houses the lingual foramen, through which the lingual artery courses.\textsuperscript{21} This artery is approximately 1–2 mm in diameter and can be seen in cross-sectional views to anastomose with the incisive canal \textsuperscript{22} (Figure 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.\textsuperscript{23} The sublingual space will fill with arterial blood, raising the tongue until the airway is compromised.\textsuperscript{24} Immediate emergency care is indicated with the possibility of tracheostomy until blood flow is controlled (Figure 6). Placement of implants at midsymphysis should be carried out with knowledge of the position of the lingual and submental arteries as well as the ridge trajectory. If bone above these vascular components is insufficient, placement of implants at midsymphysis 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 mandibles studied.\textsuperscript{25} Because such vascular canals are encountered regularly, the authors recommend a routine CT or focused cone beam computed tomography (CBCT) examination before implant surgery to help avoid severe bleeding complications during placement of implants in this region.

**Submental Artery**

More variable than the lingual artery, branches of the submental artery are seen to anastomose with the incisive canal at, or adjacent to, the symphyseal midline (Figure 7). The submental artery, a branch of the facial artery, is considered to be the main arterial blood supply to the floor of the mouth and the mandibular lingual gingival. 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, the submandibular salivary gland, the 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.  

**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 platsma 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 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 anastomoses with the incisive canal at the cuspid position (Figures 8 through 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 may be indistinguishable from surrounding bone. Anecdotal reports have described accessory foramina anterior to the mental foramen, varying in number, size, and location. With the use of 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 anastomoses 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 (Figures 11 and 12).

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

**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\textsuperscript{30} (Figures 13 and 14). The secondary smaller foramen may be viewed as artifact on a periapical or panoramic film. This neurovascular component may be inadvertently injured or transected during surgery, leading to paresthesia 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 now can measure the trajectory of the planned implant relative to the opposing dentition.\textsuperscript{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.\textsuperscript{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 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 (Figure 15). In an attempt to create a more ideal emergence profile, surgeons often place implants with a more facial inclination. The available bone height may be overestimated by looking at a panorex view because of this lingual angulation. The osteotomy path may come in contact with the lingual plate prematurely, and perforation into the floor of the mouth may occur. This may damage sublingual blood vessels, resulting in a significant bleeding episode.\textsuperscript{33}

**Bone Density**

Preoperative evaluation of bone density is best accomplished with computed 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 the chance of initial implant stability and consequently implant osseointegration. The symphysis usually is composed of D1 or D2 bone (Misch classification), which has been correlated by Misch and Kirkos to measure 850 to greater than 1250 Hounsfield units. Misch also reports that failed sites in the mandible had higher than usual Hounsfield units.\textsuperscript{34} This may be a result of denser cortical bone overheating during osteotomy preparation and lack of vascularity at the site.

**Navigated Surgery**

Implant interactive software (eg, Simplant, Materialise Dental NV, Leuven, Belgium; EasyGuide, Keystone Dental, Inc, Burlington, Mass) 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 with the use of a passive navigation device, implants can be placed in positions that avoid damage to these critical neurovascular structures (Figure 16).

**Conclusion**

The use of 12-, 14-, and 16-bit focused cone beam volumetric scanners gives us unparalleled imaging of fine structures in the oral and maxillofacial region. Knowledge of intricate anatomy and our ability to avoid iatrogenic damage to critical structures in the mandibular symphysis will enhance patient care and safety. This will allow surgeons to preplan ideal implant placement.
and to make critical decisions before surgery is performed. This enhancement to our understanding of maxillofacial anatomy will enable us to move closer to fulfilling the concept of minimally invasive surgery and achieving more ideal patient outcomes.

**ABBREVIATIONS**

CBCT: cone beam computed tomography  
CT: computed tomography  
IAN: inferior alveolar nerve

**REFERENCES**


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