Avoiding Mandibular Nerve Impairment, Part One: Anatomical and Intraoperative Considerations

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INTRODUCTION

In implant dentistry, iatrogenic injuries to the third division of the trigeminal nerve are a common and complex problem. Neurosensory impairment in the mandibular posterior region affects the patient's quality of life and potentially can lead to significant medico-legal implications for the clinician. To prevent damage to this vital structure, it is imperative for the implant dentist to have a comprehensive radiographic survey of the region, a thorough knowledge of normal versus variant anatomy, and awareness of intraoperative surgical techniques to minimize the possibility of nerve impairment.

In part one of this 3-part series, anatomical and intraoperative considerations will be discussed to aid the implant dentist in avoiding neurosensory impairment complications. Part 2 of this paper will discuss radiographic and surgical technique considerations for the prevention of nerve impairments, and Part 3 will outline the evaluation and treatment protocols of nerve impairment complications. These principles and techniques have been taught to more than 5,000 dentists at the Misch International Institute during the last 30 years with overwhelming success.

ANATOMICAL CONSIDERATIONS

Mandibular Nerve

The mandibular nerve (V3) exits foramen ovale in the infratemporal fossa and enters the mandibular foramen on the medial surface of the ascending mandibular ramus. Within the mandibular canal (MC), the V3 is termed the inferior alveolar nerve as it runs obliquely and anteriorly in the ramus area and then horizontally to the mental foramen. In approximately the first molar region, the inferior alveolar nerve divides into 2 terminal branches: the incisive and mental nerves.1 The mental nerve passes through the mental foramen with 3 nerve branches. One innervates the skin of the mental area, and the other 2 proceed to the skin of the lower lip, mucous membranes, and the gingiva as far posteriorly as the second premolar. The incisive nerve branch supplies innervation to the mandibular first premolar, canine, and incisor teeth. The exact location of the inferior alveolar nerve within the body of the mandible must be accurately determined to avoid neurosensory disturbances secondary to implant placement.

Position of the Mandibular Canal Varies

In implant dentistry today, a common belief exists that the vertical position of the MC is relatively constant below the apices of the natural teeth within the mandible. However, studies have confirmed the inferior-superior (vertical)
positions of the MC are not consistent and wide variation exists. An early classification of the vertical intraosseous course of the inferior alveolar nerve was reported by Carter and Keen. They described 3 distinct types: (1) in close approximation to the apices of the teeth, (2) a large nerve approximately in the middle of the mandible with individual nerve fibers supplying the mandibular teeth, and (3) a nerve trunk close to the inferior cortical plate with large plexuses to the mandibular teeth. Further studies have classified the intraosseous position as either high (~48%), intermediate (~3%), or low (49%). In summary, the vertical intraosseous path of the MC is variable within the mandible, and a comprehensive radiographic survey ideally should be completed prior to implant osteotomy initiation to determine the anatomic path (Figure 1).

Generally, in the posterior region of the mandible, the MC lies close to the lingual cortical plate, and as it progresses anteriorly near the mental foramen, the position is close to the buccal plate. In between, the MC is extremely variable with respect to the orientation in the buccal or lingual planes. Studies have shown there exists a high degree of variability, and the location is dependent on such variables as the amount of bone resorption, age, and ethnicity. Other studies have reported the crossover from lingual to buccal to be in the first molar region or the second premolar region. Thus, 3-D, cross-sectional images should be utilized to determine the true position of the MC in the buccal-lingual dimension (Figure 2).

Understand Variations in the Location of the Mental Foramen

Determining the exact location of the mental foramen is crucial when placing implants in the posterior mandible. Although the mental foramen has been shown to be symmetrical to the contralateral side in most patients, the location has been shown to be highly variable. Clinically, when placing implants near the mental foramen, the exact location must be determined to avoid nerve damage.

1. Palpation. In rare cases, the implant dentist may be able to palpate the location of the mental foramen. Most notably, when bone resorption has caused the nerve to be exposed on the residual ridge, the concavity formed by the exposure of the nerve can be easily palpated. In these cases, the location of the mental foramen may be marked with a surgical pen. However, when the nerve is located on the buccal surface of the mandible, the palpation method of identification has very low utility (Figure 3a).

2. Anatomic Landmarks. Many authors have postulated that landmarks such as teeth and mandibular bony areas may help identify the location of the foramen. Studies have
shown no correlation with the location of the mental foramen and a particular tooth (ie, first premolar, second premolar, between apices of the premolars) or anatomic structure. The location has been shown to be variable anywhere between the canine and as far posterior as the first molar with a significant dependence on gender, age, and race.9 The use of certain bony landmarks (ie, alveolar ridge, mandibular symphysis, and infraorbital foramen) have been associated with a general location of the foramen, although these measurements are extremely variable and dependent on the extent of bone resorption, skeletal relationships, and anatomic variants (Figure 3b).

3. **Two-Dimensional Radiographs.** Studies have shown that in more than 50% of periapical and panoramic radiographs, the mental foramen is not in the location as depicted on the image.10 Conventional 2-D radiography should never be used as the sole diagnostic modality in evaluating the foramen position.

4. **Three-Dimensional Radiography.** The literature has shown that 3-D imaging is the most accurate radiographic modality to ascertain the exact location of the mental foramen. Reformatted 3-D images and panoramic images are the easiest and most accurate way of determining exact foramen location.
5. **Direct Evaluation.** The most precise technique available today to determine the exact location of the mental foramen is by direct evaluation. A full thickness reflection is carried out to reflect the tissue anterior and posterior to the mental foramen. A wet gauze is used to gently expose the coronal aspect of the mental foramen. This procedure can be accomplished with very low morbidity; however, it is dependent on the implant dentist's training and experience (Figure 3c).

6. **Three-Dimensional Ultrasound.** The most promising imaging technique for mental foramen identification in the future is ultrasound. Ultrasound has the advantage of no ionizing radiation and the ability to reconstruct 3-D images of bone surfaces to within an accuracy level of 24 µm. However, at this time, ultrasound units are not available that are specific for dental use (Figure 3).

**Always Evaluate the Patient for Accessory (Double) Foramens**

Studies have shown in approximately 2% to 10% of patients, an accessory (double) foramen is present. In the majority of patients, small accessory foramens usually contain a small branch of the mental nerve, which are not problematic because of cross innervation. However, in some cases, a larger branch of the mental nerve (equal or larger size foramen) may exit the mental foramen. Special care should be extended in this area as it may contain components of one of the 3 branches of the mental nerve. Accessory foramens are believed to be the result of early branching of the inferior alveolar nerve, prior to exiting the mental foramen during the twelfth week of gestation. Double foramens are easily seen in reformatted 3-D and coronal images (Figure 4).

**Evaluate for Anterior Loops of the Mental Nerve**

As the mental nerve proceeds anteriorly in the mandible, it sometimes will extend beyond the anterior boundary of the mental foramen. This anterior and caudal component of the mental nerve is termed an “anterior loop,” which will exit the mental foramen in a posterior direction. Recently, CT and
dissection studies have shown a higher prevalence (~70%) of anterior loops than what was once thought with a mean distance of 1.16 mm anteriorly. The anterior loop may be depicted most predictably on reformatted axial CT images with 2-D radiographs being totally unreliable. Clinically, an anterior loop may be determined by probing within the mental foramen in a posterior direction. The importance of determining the presence of an anterior loop is critical when placing implants anterior to the mental foramen. Inability to establish the existence of an anterior loop may result in neurosensory impairment of the mental nerve (Figure 5).

Do Not Confuse the Incisive Nerve Branch as an Anterior Loop
The incisive nerve branch has no sensory innervation; thus implants may be placed in proximity to this nerve without neurosensory impairment. Studies have shown that incisive canals have a mean diameter of 1.8 mm with an approximate location 9.7 mm from the lower cortical border. The incisive nerve has been recognized as an important anatomic structure that must be taken into consideration when performing surgery in this area. It is frequently mistaken as an anterior loop in the mandible. Excessive bleeding has been reported as a significant intraoperative complication in this area when perforated during osteotomy preparation (Figure 6).

INTRAOPERATIVE CONSIDERATIONS
Utilize the “Misch Zone of Safety Principle”
To prevent impingement of a dental implant on the inferior alveolar nerve or mental foramen, Misch and Crawford in 1990 identified the “zone of safety” concept. The zone of safety technique reflects the measurement from the superior aspect of the mental foramen to the crest of the alveolar ridge. It was concluded that the vertical height of bone coronal to the mental foramen is present 100% of the time posterior to the middle half of mandibular first molar, and 97.5% of the time to the distal of the first molar. Additionally, the corresponding safety height measurement extends posterior to the mesial half of the second molar 43% of the time (Figure 7).

Maintain a Safety Zone
A 2.0-mm safety zone with osteotomy preparation and final implant placement is paramount in preventing neurosensory impairments. Compression-related injuries (neuropraxia) can occur by encroaching on the inferior alveolar nerve (IAN) without actual contact or invasion of the MC. Bleeding and resultant hematomas have been shown to cause nerve damage because of final implant positioning too close to the neurovascular canal. Additionally, the IAN superior cortical bone can be compressed, thus causing pressure necrosis, with resultant nerve impairment. Interactive treatment planning software programs (ie, SimPlant [Materialize Dental]) allow the implant dentist to accurately assess the ideal placement and insure adequate distance from the MC.

Understand the True Implant Bur Drilling Depths
Care should always be exercised when performing osteotomies over vital structures, most importantly in the posterior mandible. The implant dentist should always double check the marking depth on the burs prior to initiating the osteotomy. The principle of measure twice and drill once should be followed to prevent iatrogenic overpreparation of the implant site. Also, the dimension of the implant system being used must be known. The depth of the millimeter lines inscribed on surgical drills do not always coincide with the actual depth of the drill. Most drills
contain a v-shaped apical portion, which is designed for cutting efficiency (y dimension). Usually, the wider the drill, the greater the y dimension. Therefore, the implant dentist should always evaluate the manufacturer's drill length with respect to the length of the implant prior to performing the osteotomy. If this concept is not adhered to, overpreparation of the site may occur, resulting in nerve damage (Table).

**Use Drill Stops to Prevent Overpreparation**

To obtain precise depth control during osteotomy preparation, the use of special drills with predetermined “stops” can be used. These stop drills prevent overpreparation of the osteotomy site and are extremely beneficial in the mandibular posterior area, especially when visibility and access are compromised. Generic drill stop kits are available which may be used universally with most implant surgical systems (ie, Salvin Corp Drill Kit). This autoclavable, reusable kit may be used with all implant systems and corresponds to any size length implant and corresponding drill (Figure 8).

**Understand Bony Crest Anatomy**

After extraction, normal bone resorption results with the alveolar ridge becoming compromised in width (Division B Bone) at the expense of the buccal plate. When measuring available bone height, special consideration should be given to the final location of the superior aspect of the implant platform, not the crest of the ridge. It will often appear that adequate vertical height for implant placement is sufficient; however, when the osteotomy is initiated, the thin crest will be lost, thus the implant will be placed inferior to where it is originally intended. This can lead to unexpected depth drilling and an implant that is placed too close to the MC. Thus, the clinician should either augment the ridge to maintain vertical height or reduce the height calculation by the amount of osteoplasty during osteotomy preparation (Figure 9).

**Maintain Total Control of the Handpiece**

When performing osteotomies in the posterior mandible, special care should be noted to maintain complete control of the surgical handpiece. Large marrow spaces (lack of or thin trabecular bone) are often present, which may allow the osteotomy site to become deeper than expected. This will result in the implant being placed more apically, leading to neurosensory impairment. A CBCT comprehensive evaluation will allow the implant dentist to evaluate the bone quality prior to surgery. Additionally, when drilling osteotomy sites near the mental foramen, care should be exercised not to bend the wrist when drilling the osteotomy. This can potentially redirect the drill or implant placement in an unwanted position (ie, near the mental foramen, into a tooth root). Also, to minimize this complication, surgical templates and guides may be utilized (Figure 10).

**Do Not Place Bone Graft Material in Close Approximation to the Nerve**

After mandibular posterior tooth extractions, especially in the mandibular premolar areas, care should be exercised in placing bone graft material (autologous, allogenic, xenogenic) in direct contact with an exposed MC. Whether
socket grafting or in conjunction with implant placement, case studies have shown resultant neurosensory impairment from bone graft material causing compression, crushing, or chemical burn injuries.\textsuperscript{18} When socket grafting in this area is indicated, excessive pressure should be avoided when placing the graft material (Figure 11).

**Use Copious Irrigation**

Overheating the bone during osteotomy preparation may produce thermal stimuli, which may lead to peri-implant necrosis and secondary postoperative nerve damage. The thickness of the necrotic area is proportional to the amount of heat generated during preparation.\textsuperscript{19} Thus, the implant dentist must be cautious with respect to overheating the bone. This can be minimized by “bone dancing,” which involves drilling in short intervals and allowing irrigation to enter the osteotomy. Additionally, new (sharp) and intermediate sized drills burs may be used to reduce heat generation along with secondary irrigation. Overheating the bone is more critical when harder bone density or bone with compromised vascularity is present (Figure 12).

**Avoid Injuries Related to Incisions**

When making crestal or release incisions in approximation to the mental foramen, extreme caution should be noted. In cases of severe bone atrophy, the presence of nerve dehiscence may inadvertently result in a transected nerve during the initial incision. Anatomic landmarks, 3-D models, accurate measurements from the CBCT scan, or palpation of the nerves are ways to avoid this complication. Furthermore, incisions in the posterior of the oral cavity should never be made over the retromolar pad. This can result in possible injury to the lingual nerve, which in 10\% of cases transects this area (Figure 13).

**Avoid Injuries Related to Flap and/or Retraction**

Neurosensory impairments may also occur from overzealous use or incorrect placement of tissue retractors. Broad base (not sharp) retractors should be used to retract tissue not directly over the mental foramen, as excessive stretching of the nerve trunk may cause irreversible damage. It is imperative that the mental foramen and associated branches of the mental nerve be identified in this area when placing retractors. Retractors should always be placed and held on the bone as to prevent slippage or excessive soft-tissue pressure, which may lead to a neuropraxia type of nerve damage (Figure 14).

**Use Extra Care When Releasing Periosteum Over the Mental Foramen**

A common procedure during closure after implant placement or bone grafting is to stretch the periosteal tissue to allow primary and “tension-free” closure. This may become problematic when stretching tissue in approximation to the mental nerve branches. Various techniques are used to “release” the tissue to improve vascularization of the incision line and adhesion of the margins to prevent incision line opening. The submucosal technique developed by Misch\textsuperscript{17} in 1988 is an effective method to expand the tissue. This procedure involves the use of a No. 15 scalpel blade and soft-tissue scissors (ie,
Metzenbaum) to create a blunt dissection. Knowledge of the location of the 3 mental nerve branches is necessary as inadvertent incisions over the mental area may result in neurotmesis (transection) types of nerve injuries (Figure 15).

**Careful Suturing**

When the mental nerve branches are exposed, care should be exercised to prevent neural tissue from being entrapped within the sutures. The mental nerve emerges from the mental foramen and divides into 3 branches below the depressor anguli oris muscle. Compressing the nerve with suture material may potentially cause a neuropraxia (compression) type of nerve injury. Also, nerve fibers may be damaged from the passage of the extremely sharp suture needle through the neural tissue (Figure 16).

**Verify Correct Positioning of CBCT Surgical Guides**

Studies have shown that the most precise and accurate CBCT surgical guides are tooth-supported. When using bone- or tissue-supported surgical guides, care must be exercised to correctly position the guide, as an error in placement may result in direct damage to the inferior alveolar nerve. Tooth-supported guides should always be the first choice if possible, as they are clinically proven to have the least amount of positioning errors. The least accurate guide is mucosa-supported, which is most utilized for flapless surgery.20 Studies have shown that flapless surgical guides consistently show deviations of implant positions from ideal locations. Perforations of the buccal plate can be found in more than 50% of the flapless cases.21 A very minor discrepancy (anterior-posterior) in the placement of the guide can lead to impingement on vital structures (Figure 17).

**SUMMARY**

In implant dentistry today, one of the most serious complications is inferior alveolar nerve impairment associated with mandibular posterior implant placement. It must be understood that the inferior alveolar neurovascular bundle is anatomically variable with inconsistent intraosseous paths. The gender, age, race, and degree of alveolar bone atrophy largely influence these variations. Knowledge of the involved anatomy, treatment planning, and surgical techniques and procedures will reduce the possibility of neurosensory related complications. If nerve injury does occur, early and proper management is the key to maximizing the chances of recovery.

**REFERENCES**

4. Nortjé CJ, Farman AG, Grotepass FW. Variations in the normal anatomy of the inferior dental (mandibular)


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1. Studies have confirmed the inferior-superior (vertical) positions of the MC are consistent and wide variation does not exist.
   a. True  b. False

2. Although the mental foramen has been shown to be symmetrical to the contralateral side in most patients, the location has been shown to be highly variable.
   a. True  b. False

3. Studies have shown that in more than 80% of periapical and panoramic radiographs, the mental foramen is in the location as depicted on the image.
   a. True  b. False

4. Studies have shown in approximately 2% to 10% of patients, an accessory (double) foramen is present.
   a. True  b. False

5. The anterior loop may be depicted most predictably on reformatted axial CT images; however, even 2-D radiographic depiction is totally reliable.
   a. True  b. False

6. Studies have shown incisive canals have a mean diameter of 1.8 mm with an approximate location 9.7 mm from the lower cortical border.
   a. True  b. False

7. Bleeding and resultant hematomas have been shown to cause nerve damage because of final implant positioning too close to the neurovascular canal.
   a. True  b. False

8. The principle of “measure twice and drill once” should be followed to prevent iatrogenic over preparation of the implant site.
   a. True  b. False

9. The thickness of the necrotic area is proportional to the amount of heat generated during preparation.
   a. True  b. False

10. Additionally, incisions in the posterior of the oral cavity should always be made over the retromolar pad.
    a. True  b. False

11. When the mental nerve branches are exposed, care should be exercised to prevent neural tissue from being entrapped within the sutures.
    a. True  b. False

12. The most accurate guide is mucosa-supported, which are most utilized for flapless surgery.
    a. True  b. False
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