Avoiding Mandibular Nerve Impairment, Part 2

Radiographic and Surgical Techniques

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INTRODUCTION

In part one of this article, the anatomic and intraoperative considerations were discussed as related to the prevention of neurosensory impairments following dental implant placement in the posterior mandible. In part 2, the radiographic evaluation and various surgical techniques will be reviewed to assist the implant dentist in decreasing the possibility and incidence of nerve-related complications. Neurosensory impairment complications of the mandibular nerve are most frequently an inadvertent sequela of improper diagnosis, treatment planning, or surgical technique. Thus, because of the complexity and variation of the anatomic position of the inferior alveolar nerve (IAN), a comprehensive radiographic evaluation is indicated to determine the ideal position for a dental implant with respect to the mandibular nerve. Additionally, a review of various “alternative” surgical techniques that may predispose the patient to nerve related problems will be discussed. In Part 3 of this article series, the postoperative management and protocol for the treatment of nerve impairment will be reviewed.

RADIOGRAPHIC CONSIDERATIONS
Understand the Disadvantages and Limitations of 2-D Radiography

Today, the sole use of 2-D radiography for treatment planning of dental implant patients is becoming less common. Two-dimensional radiographs, mainly panoramic, have many inherent disadvantages in evaluating potential implant sites. All panoramic (2-D) radiographs exhibit some degree of distortion, non-uniform magnification, and image superimposition that can potentially lead to incorrect measurement and assessment of neural structures. Likewise, the mandibular canal depicted on panoramic images is not always clearly defined because of inconsistent and sclerotic borders. Studies have confirmed that periapical and panoramic radiography modalities are unreliable and incorrect in assessing the exact location of the mandibular canal. It has been reported that on panoramic images, the mandibular canal is invisible in approximately 36% of images. Furthermore, the superior border of the canal is not visible in 64% of radiographs. Thus, extreme caution should be exercised when using 2-D radiography as the sole radiographic modality for implant site evaluation (Figure 1).
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radiographs to assist in the placement of implants over vital structures. Caution should be noted, in that panoramic and periapical radiographs have variable magnification (not 25%, as indicated by most manufacturers), and even calibrated intraoral software programs cannot accurately assess true distances because of their inherent 2-D origin. Magnification is influenced by many factors, including skeletal size and relationship, beam angle, curvature of the alveolus, patient positioning, and panoramic unit type. Site location within the anatomic arch can affect the amount of magnification to approximately 32%.4 Studies have shown that, in more than 70% of cases, when implant size was initially determined via panoramic radiographs, the final implant size had to be altered after cone beam CT (CBCT) evaluation.5 Therefore, magnification guides should never be used as the sole criteria for implant site evaluation as they may lead to overestimation of available bone dimensions (Figure 2).

3-D Radiography Is the Most Accurate Type of Radiographic Modality

In most implant cases, a 3-D radiographic modality is recommended for evaluation of implant placement and related nerve anatomy in the mandibular arch. To determine the ideal location and measurement parameters associated with the implant placement, the clinician must be able to accurately measure the distance between the alveolar crest and the superior border of the mandibular canal, and also the width of bone in the proposed implant site. Medical slice CT (MSCT) and CBCT images have been shown to be the most accurate radiographic modalities in the assessment of available bone and identification of the IAN.6 The use of CBCT radiographs have become successful due to volumetric bone imaging and low radiation doses, as well as the advantage of having affordable and compact in-office radiographic units. Therefore, a thorough knowledge of the relative 3-D position of the IAN is crucial in preventing nerve impairment prior to implant placement (Figure 3).

Use Interactive Treatment Planning Software to Evaluate the Posterior Mandible

Because MSCT and CBCT have been shown to be 1:1 (no magnification), the implant dentist has the ability to place implants, measure available bone, determine ideal angulation, evaluate bone density, and order surgical templates directly from the computerized treatment plan. The integration of 3-D data with interactive treatment planning software programs allow the clinician to accurately access the size, type, and ideal placement of the implant in relation to anatomical structures. With comprehensive implant libraries, the implant dentist may evaluate the exact implant parameters (ie, thread design, platform size) via virtual treatment planning. This virtual treatment plan may then be transferred to the patient’s surgery by means of a surgical template or computer-assisted navigation device (Figure 4).

Use of Bone Models

The fabrication of a stereolithographic bone model can be an invaluable preoperative diagnostic tool for treatment planning and surgical simulation for the implant dentist. Bone models are made directly from the CBCT DICOM data, which involve the principle

Figures 3a to 3c. (a) Cone beam CT (CBCT) unit. (b) Comprehensive evaluation of the mandibular arch and related nerve anatomy from reformatted DICOM images. (c) Implant placement with SimPlant software (Materialise Dental) with integrated 2.0 mm safety zone from inferior alveolar nerve (IAN).
of stereolithography (a type of 3-D printing) and a rapid prototyping machine. These models allow the clinician to evaluate the exact osseous morphology (i.e., width of bone, undercuts, bony landmarks) and location of vital structures (color-coded within the model) prior to the actual surgery. Because of the transparent nature of bone models, the intraosseous course of vital structures such as the inferior alveolar canal are easily visible and identified. Also, the stereolithographic material allows the dentist to simulate implant osteotomies, bone grafts, and placement of fixation screws in a laboratory setting prior to live surgery (Figure 5).

**Use of Surgical Templates**

When placing implants in sites with anatomic restrictions (such as in the posterior mandible), the use of surgical templates is extremely helpful. This technique allows the dentist to place implants with the highest degree of accuracy as the gingival templates provide drill guidance with depth control. Basically, the surgical guide is the conduit for transferring the interactive treatment plan from the computer to the patient’s actual surgical procedure. This allows the clinician to place the implants in the exact location per the treatment plan in all spatial planes. Surgical guides are fabricated with many different materials; however, these are universally termed with respect to the method of retention: tooth-, bone-, or mucosa-supported. The SAFE SurgiGuide (Materialise Dental) is an example of a surgical template that allows the practitioner the ability to place the implant via an interactive treatment plan in the mesial-distal, buccal-lingual, and apico-coronal dimensions with 3 types of guides. Guided surgery, with surgical templates, has been reported to improve the accuracy of implant placement within clinical situations, in comparison to conventional surgical methods. So, in the posterior mandible, a depth-controlled surgical guide is an important adjunct for the placement of implants at the exact depth, decreasing possible nerve complications (Figure 6).

**MISCELLANEOUS ALTERNATIVE SURGICAL TECHNIQUES**

**Use Caution When Placing Immediate Implants in the Mandibular Posterior Area**

Immediate implants have gained overwhelming popularity in
today’s implant dentistry. However, care must be exercised when extracting and immediately placing implants in the mandibular posterior region. As noted in part one of this article, there exists great variability in the exact location of the mental foramen and mandibular canal in the vertical and horizontal planes. Studies have shown that in approximately 25% to 38% of patients, the mental foramen is superior to the premolar’s apex. More than 30% of the time, the mandibular canal will be in direct contact with the root apex of mandibular posterior teeth, regardless of age; and females show greater incidence of root apex-to-canal approximation. Because most immediate implant osteotomy sites involve drilling the osteotomy site deeper for stability, chances of nerve trauma are greatly increased. Therefore, the implant dentist must be very selective with treatment plans involving extraction and immediate implant placement in the posterior area. Pre-extraction CBCT examinations are an invaluable diagnostic modality to determine tooth and bone morphology along with the distance from the root apex to the mental foramen and mandibular canal (Figure 7).

**Drill Until the Superior Cortical Plate is “Felt”**

It has been advocated in the literature that the osteotomy depth may be determined by “feeling” the superior cortical plate of the mandibular canal. A 2.0-mm safety zone should always be adhered to as research has shown in approximately 28% of posterior mandibles, there exists no superior cortical plate over the mandibular canal. Also, studies have shown a very low probability in tactilely differentiating cancellous bone from the superior cortical plate of the mandibular canal. Clinical reports have revealed nerve damage and hemorrhage from placing implants in approximation to the mandibular nerve without entering the canal, as bone fragments may cause compression or ischemia of the nerve, resulting in a neuropraxia (Figure 8).

**Place Implants at the Depth of the Adjacent Root Apices**

Many implant dentists use the location and length of the adjacent teeth as a guide in determining the size (length) of implant to be placed. Usually a panoramic or periapical radiograph is used in determination of this length. When this technique is used in anatomic type II or III (more apically positioned in the vertical dimension) nerve courses, incidence of nerve impairment is low. However, in mandibles that exhibit a type I nerve course, close approximation of the implant to the canal will likely lead to a higher probability of neurosensory impairment. Ideally, the dentist should ascertain the available bone above the mandibular canal via 3-D radiographic analysis (Figure 9).

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**Figures 8 and 8b.** (a) In approximately 28% of cases, no superior cortical plate is present. (b) Even when present, the cortical plate is very thin, which makes tactile sensitivity very difficult.

**Figures 9a and 9b.** (a) Placement of implants at the level of the adjacent roots is ideal when an anatomic type II or III nerve is present. (b) In type I nerve courses, this principle will lead to a greater chance of nerve impairment because of approximation of the implant and mandibular canal.

**Figure 10.** Many alveolar branches are present from the main IAN trunk to the teeth and edentulous areas leading to questionable responses from patients.

**No-Block or Infiltration Technique**

An alternative technique in the literature for placing implants in the posterior mandible is to utilize infiltration anesthesia instead of conventional mandibular nerve block anesthesia. With the infiltration technique, only the soft tissue surrounding the osteotomy site is anesthetized. The patient is then asked to “sense” and alert the dentist on the proximity of the drill to the nerve bundle. This unconventional surgical technique results in a very high degree of subjectivity concerning the patient’s responses due to varying degrees of pain thresholds. Likewise, disadvantages of this surgical method include inconsistent mandibular nerve anatomy with varying locations of dental alveolar nerve branches, false-positive and false-negative responses, and a possible negative surgical experience for the patient. With the current success of CBCT radiography in implant dentistry in determining the exact location of the IAN, this technique should be avoided because of the increased possibilities of inaccurate responses from patients (Figure 10).
If Excessive Bleeding Is Not Present, the Mandibular Canal Has Not Been Violated
Another unconventional technique in avoiding nerve impairment is the evaluation of the amount of bleeding from the osteotomy site. Many practitioners correlate the amount of hemorrhage with the proximity of the neurovascular bundle (IAN, artery, vein, and lymphatic vessels). Anatomic studies have shown the inferior alveolar artery to be solitary, and lies superior and lingual to the IAN, slightly above the horizontal position. Other studies have shown multiple inferior alveolar veins positioned superior to the nerve, which may cause venous oozing if directly traumatized. Additionally, a false positive may occur as large marrow spaces, which can cause excessive bleeding, are common in the posterior mandible (D4 bone). Thus, the degree of bleeding should not be used as an indication of nerve proximity or violation of the mandibular canal (Figure 11).

Place Implants Buccal or Lingual to the Inferior Alveolar Nerve Canal or Foramen
Many authors have advocated placing implants buccal or lingual to the neurovascular bundle. As shown in part one of this article series, the buccal-lingual nerve position within the mandible is extremely variable along with the incidence and trajectory of lingual osseous concavities. Attempting to place implants buccal or lingual to the mandibular canal or mental foramen is associated with a high degree of morbidity, even with the use of CBCT guided surgery. Also, an accurate assessment of the lingual concavity should be determined, as inadvertent perforation of the cortical plate can occur, which may lead to sublingual bleeding or formation of a sublingual hematoma, chronic irritation, and infection. Studies have shown posterior lingual concavities occur in approximately 70% of the population with a mean concavity 2.4 mm at the level 2.0 mm coronal to the mandibular canal (Figure 12).

Replacing Second Molars
There exist many prosthetic and surgical disadvantages when evaluating edentulous second mandibular molar sites for implant placement. Disadvantages include: high incidence of sublingual bony undercuts which can result in perforation of the lingual plate or angulation issues; decreased interocclusal space (especially with supra-eruption of the adjacent tooth); difficult access for surgery and prosthetic component insertion; 10% greater occlusal force measured on the second molar versus the first molar; function is not a primary reason for replacement, as 90% of masticatory efficiency is generated anterior to the mesial half of the mandibular first molar; and, cheek biting is more common in this area because of the proximity of the buccinator muscle. However, one of the most important disadvantages is the close approximation of the mandibular canal in the second molar area, leading to difficulty in placement of implants in this area. When implants are placed, usually the available bone present is compromised in height. As a result, the second molar is often not replaced when the only posterior teeth missing are the second and third molars. The primary disadvantage of not replacing the second molar is extrusion of the maxillary second molar. If extrusion is a significant concern, a full coverage crown on the mandibular first molar may include an occlusal contact on with the mesial marginal ridge of the maxillary second molar (Figure 13).

Nerve Repositioning
Patients who exhibit compromised alveolar crest height in the posterior mandibular area can be very challenging. Techniques
include the use of shorter implants, which become biomechanically compromised, or the use of bone grafting to increase available bone for future implant placement. An alternative technique is to reposition the IAN laterally, either by nerve lateralization or nerve transposition. In nerve lateralization, the IAN is exposed and retracted laterally while the implants are placed. The transposition technique, first published in 1987 by Jensen and Nock, includes the mental foramen in the osteotomy resulting in the IAN being positioned more posteriorly. The inherent risk with these complex procedures is neurosensory impairment (anesthesia, paraesthesia, or dysesthesia) to the mental nerve branch. Although this is a valid treatment option in significant atrophied cases, this technique should be reserved for practitioners with advanced training and experience with these procedures.

**SUMMARY**

In contemporary implant dentistry, one of the most serious complications is IAN impairment associated with mandibular posterior implant placement. To avoid nerve damage, a thorough understanding of the radiographic anatomy is paramount. The mandibular canal and mental foramen are associated with inconsistent anatomical locations. The implant dentist should understand the limitations of 2-D radiology along with the importance of a comprehensive radiographic evaluation of the neural anatomy of the mandible. Furthermore, the dentist must understand the limitations of unconventional surgical techniques that may increase the morbidity of the procedure.

**REFERENCES**

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1. Studies have confirmed that periapical and panoramic radiography modalities are reliable and correct in assessing the exact location of the mandibular canal.
   a. True  b. False

2. Magnification guides should always be used as the sole criteria for implant site evaluation.
   a. True  b. False

3. The use of CBCT radiographs have become successful due to volumetric bone imaging and low radiation doses, as well as the advantage of having affordable and compact in-office radiographic units.
   a. True  b. False

4. Because of the transparent nature of bone models, the intraosseous course of vital structures such as the inferior alveolar canal are easily visible and identified.
   a. True  b. False

5. In the posterior mandible, a depth-controlled surgical guide is often an unreliable adjunct for the placement of implants at the exact depth, and does not significantly decrease possible nerve complications.
   a. True  b. False

6. Studies have shown in approximately 25% to 38% of patients, the mental foramen is superior to the premolar’s apex.
   a. True  b. False

7. Ideally, the implant dentist should ascertain the available bone above the mandibular canal via 3-D radiographic analysis.
   a. True  b. False
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8. The inferior alveolar artery appears to be solitary and lies superior and lingual to the inferior alveolar nerve, slightly above the horizontal position.
   a. True  b. False

9. The degree of bleeding should always be used as an indication of nerve proximity or violation of the mandibular canal.
   a. True  b. False

10. Studies have shown posterior lingual concavities occur in only 25% of the population with a mean concavity 2.4 mm at the level 2.0 mm coronal to the mandibular canal.
    a. True  b. False

11. When implants are placed, usually the available bone present is compromised in height. As a result, the second molar is often not replaced when the only posterior teeth missing are the second and third molars.
    a. True  b. False

12. Patients who exhibit compromised alveolar crest height in the posterior mandibular area can be very challenging.
    a. True  b. False
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Please check the correct box for each question below.

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3.  ❑ a. True  ❑ b. False
4.  ❑ a. True  ❑ b. False
5.  ❑ a. True  ❑ b. False
6.  ❑ a. True  ❑ b. False

7.  ❑ a. True  ❑ b. False
8.  ❑ a. True  ❑ b. False
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