

Inferior Alveolar Nerve Injury in Implant Dentistry: Diagnosis, Causes, Prevention, and Management

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Inferior alveolar nerve injury is one of the most serious complications in implant dentistry. This nerve injury can occur during local anesthesia, implant osteotomy, or implant placement. Proper understanding of anatomy, surgical procedures, and implant systems and proper treatment planning is the key to reducing such an unpleasant complication. This review discusses the causes of inferior alveolar nerve injury and its diagnosis, prevention, and management.

Key Words: *inferior alveolar nerve, nerve injury, complication of dental implant, diagnosis of nerve injury, management of nerve injury*

INTRODUCTION

Dental implantology has become a widely accepted mode of treatment. Because of its ability to restore esthetics and function, it has become the preferred option for replacing hopeless and missing natural teeth. Despite its high success rate, however, many complications have been encountered with its use.

One of the most serious complications is the alteration of sensation after implant placement in the posterior mandible. The prevalence of such a complication has been reported as high as 13%.^{1,2} This can occur as a result of injury to the inferior alveolar nerve (IAN) or the lingual nerve from traumatic local anesthetic injections or, most important, during dental implant osteotomy or

placement.³ This complication is one of the most unpleasant experiences for both the patient and the dentist, so every precaution should be taken to avoid it. Once it happens, the dentist should provide the patient with appropriate care and should know when to refer the patient to a microneurosurgeon.

Depending on the degree of nerve injury, alteration in sensation varies from mild paresthesia to complete anesthesia. Also, it may be transient, manageable, or, in certain cases, permanent. The purpose of this article is to provide guidelines for prevention and management of IAN injury during dental implant placement in the posterior mandible.

ALTERATION OF SENSATION

Alteration of sensation can occur in the form of paresthesia, dyesthesia, analgesia, or anesthesia. *Paresthesia* is an alteration in sensation that can be felt as numbness,

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TABLE
Clinical neurosensory tests^{8,29,30}

Name of Test	Description
Mechanoceptive	
Static light touch detection	Patient is asked to tell when he/she feels light touch on the face and to point to the exact location.
Brush directional discrimination	Patient is asked to tell when he/she feels the brush and to determine the direction of movement.
Two-point discrimination	Patient is asked to determine single and 2 points of touch. The examiner uses any 2 instruments by which the patient can change the distance between them.
Nociceptive	
Pin pressure nociception	Patient is asked to determine the feeling of a pin prick.
Thermal discrimination	Patient is asked if he/she feels cold or heat.

burning, or prickling sensations, either evoked or spontaneous, whereas *dysthesia* is a spontaneous or evoked unpleasant abnormal sensation.⁴ *Analgesia* is the loss of pain sensation, whereas *anesthesia* is loss of perception of stimulation by any noxious or nonnoxious stimulant.⁵

Seddon⁶ classified nerve injuries as neuropraxia, axonotmesis, and neurotmesis. In *neuropraxia*, the continuity of the axon is preserved and the injury is usually temporary. *Axonotmesis* is caused by more severe injury, as the axons are disrupted but the overall structure and integrity of the neural tube remain intact. *Neurotmesis* is the most severe form of nerve injury, wherein the integrity of the neural tube becomes disrupted.

Practitioners should be familiar with these types of nerve injuries and should be able to perform standardized neurosensory examinations to determine the degree of change in sensation, should know the possible outcomes, and should decide when to refer the patient to a microneurosurgeon. The patient's neurosensory functions must be evaluated as part of the initial examination before implant treatment is started, especially patients with a history of alteration of sensory function of the IAN associated with previous implant or impacted third molar extraction.

Many neurosensory tests are available to measure the neurosensory function of the

IAN to evaluate the extent of neural damage after implant placement. These vary from easy methods that can be performed with simple instruments available in the operatory to more sophisticated procedures that require high-technology equipment.

Simple, clinical neurosensory tests are used most commonly, and they can be classified into mechanoceptive tests and nociceptive tests (Table). Each test should be performed while the patient closes his or her eyes and is in a comfortable position, away from distractions. The clinician should use the contralateral side as a control, and results must be accurately recorded.^{7,8}

INFERIOR ALVEOLAR NERVE

The mandibular nerve is the third and most inferior division of the trigeminal, or fifth, cranial nerve. The trigeminal nerve is predominantly a sensory nerve, innervating most of the face. The upper branch of the trigeminal nerve is the ophthalmic nerve, which innervates the forehead. The middle branch, the maxillary nerve, innervates the maxilla and the midface. The lower branch, the mandibular nerve, innervates the teeth and the mandible, the lateral mucosa of the mandible, and the mucosa and skin of the cheek, lower lip, and chin. The mandibular nerve contains both sensory and motor fibers. It runs from the trigeminal ganglion

through the foramen ovale and gives off 2 branches from its main trunk (meningeal branch and nerve to the medial pterygoid muscle). Then it divides into anterior and posterior divisions. The anterior branch emits 1 sensory nerve, the buccal nerve, and 3 motor branches to supply the masseter, the temporalis, and the lateral pterygoid muscles. The posterior branch of the mandibular nerve is larger than the anterior branch. It gives off 2 sensory branches, the auriculo-temporal and lingual nerves. Just before the posterior branch enters the mandibular foramen as the inferior alveolar nerve, it gives off the mylohyoid nerve, which supplies the mylohyoid and the anterior belly of the digastric muscles.⁹

The IAN is a branch of the posterior division of the mandibular nerve that contains both sensory and motor fibers. It enters the mandibular foramen, runs in the mandibular canal, and supplies the mandibular teeth. It leaves the mandibular canal through the mental foramen as the mental nerve. Within the canal, the nerve is about 3 mm in diameter, and its course varies. It can run with a gentle curve toward the mental foramen, or it can have an ascending or descending pathway.^{7,9,10}

In a recent study, Kim et al¹¹ classified the buccolingual location of the IAN into 3 types. Most cases (70%) were type 1, in which the IAN canal follows the lingual cortical plate of the mandibular ramus and body. In type 2 (15%), the IAN canal is located in the middle of the mandibular ramus posterior to the second molar. It then runs lingually to follow the lingual plate. In type 3 (15%), the IAN canal is located near the middle of the ramus and body.

A bifid IAN canal has been reported to occur very infrequently. Nortjé et al^{12,13} found an occurrence of 0.9%. Grover et al¹⁴ were able to find only 0.08% of radiographs suggestive of bifurcation of the IAN. Langlais et al¹⁵ found 0.95% of cases to have bifid IAN

canals. Despite the rare occurrence of the bifid IAN canal, the clinician must be on the lookout for these cases when planning for dental implants.

Several methods are used to localize the IAN during treatment planning. These include conventional radiography, tomography, and computerized tomography (CT). Another method is surgical exposure of the mental nerve by blunt dissection to allow direct vision of the nerve and to estimate the distance between the mandibular ridge crest and the IAN, but the irregular intraosseous course of the nerve limits the value of this surgical technique.¹⁰

CT provides the most accurate and precise method for localization of the IAN. Also, the image can be reconstructed into a 3-dimensional model that can be used as an accurate surgical guide. This 3-dimensional image is very useful in determining the buccolingual width of the bone, as well as the buccolingual position of the nerve. This allows positioning of the implant to the lingual or buccal of the nerve to avoid its injury in cases of limited bone height. Although CT is very useful in dental implantology, its high cost and level of radiation prevent it from becoming the standard of care.

To localize the IAN, most clinicians use conventional radiography (eg, panoramic views, periapicals), which is sufficient for most cases.¹⁶ Panoramic radiographs can be used safely for most cases but with some limitations. A 2-mm safety zone between the apical part of the implant and the upper border of the IAN canal is strongly recommended by most implant manufacturers and practitioners.^{1,17} The magnification of the X-ray machine must be known; some recommend placing an object of known dimension in the mouth before taking the radiograph. This technique allows accurate calculation of the dimensional changes in the panoramic radiograph.

Conventional radiography produces only a 2-dimensional record; therefore, other methods must be used to overcome this problem. Palpation and bone sounding under local anesthesia are helpful in determining the buccolingual width of the ridge. In many cases, the crest of the ridge is too thin, in which case the implant surgeon should consider these few millimeters to be useless for implant support.¹⁸

Clinicians who depend mainly on the panoramic radiograph for localizing the IAN must take some factors into consideration. The IAN canal typically appears as a well-defined radiolucent bundle with superior and inferior radiopaque borders. The clinician must follow the canal from the mandibular foramen to the mental foramen and must keep in mind that magnification is a built-in feature of panoramic radiographs. Knowing the magnification factor, the clinician can calculate the amount of available bone using the formula,

$$\begin{aligned} &\text{Clinical bone height} \\ &= \text{Radiographic bone height} / \\ &\quad \text{Magnification factor} \end{aligned}$$

where radiographic bone height is the measurement on the radiograph from the crest of the ridge to the superior border of the IAN canal, and the magnification factor is a known number (ie, if a certain X-ray machine produces 30% magnification, the magnification factor will be 1.3, and if the magnification is 25%, the magnification factor will be 1.25).

After calculating the clinical bone height, the surgeon must remember to subtract the 2-mm safety zone between the implant and the superior border of the IAN. Clinicians must also bear in mind that the crest of the ridge may contain very thin bone that cannot be used for implant support.

CAUSES OF AN IAN INJURY

Although injury of an IAN can occur during a traumatic local anesthesia injection,¹⁹ the most severe types of injuries are caused by implant drills and implants themselves. In addition, flap retraction and pressure on the mental nerve area can cause injury to that nerve, resulting in altered sensation after surgery.²⁰ For appropriate management, the exact cause of injury should be recognized.

As mentioned earlier, proper localization of the IAN and accurate measurement of the available bone are of extreme importance to avoid IAN injuries. Another important point is that many implant drills are slightly longer, for drilling efficiency, than their corresponding implants. This is one example of how lack of knowledge about the implant system can cause avoidable complications.¹⁷ Even after accurate measurement of available bone, nerve injury can occur as the result of overpenetration of the drill owing to low resistance of the spongy bone; this can lead to slippage of the drill even by experienced surgeons.¹⁸

Immediate implantation following tooth extraction can sometimes cause nerve damage. Efforts by the surgeon to achieve primary stability can lead to unintentional apical extension and nerve injury. Remeasurement of the amount of available bone after tooth extraction is recommended when nerve proximity is expected because when the tooth is in situ, a misleading measurement of the bone crest might be made. In addition, a few millimeters of the crestal bone might be lost during extraction.

PREVENTION OF IAN INJURY

Accurate measurement of the bone available for implant support coronal to the IAN canal is the only way to avoid IAN injuries. The use of CT-based surgical stents or navigation systems may also help prevent nerve injury.¹ Some practitioners recommend the use of "drill

guards" provided by some implant systems. These guards are attached to the drill close to the handpiece to prevent overpenetration of the drill into the bone.¹⁸ Many clinicians prefer the use of transverse alveolar implant techniques to slant the implant laterally to engage the cortical buccal bone, in an attempt to avoid IAN injury.²¹

Heller et al²² advocate the practice of using infiltration for local anesthesia instead of an IAN block, because without complete lack of sensation, the patient will feel pain if the drill approaches the IAN canal—a significant indication to stop drilling. At the same time, an intraoperative radiograph with the presence of the drill or other gauge in the osteotomy site is of great value, especially if nerve approximation is expected.

MANAGEMENT OF IAN INJURY

If intraoperative nerve injury is suspected, it must be recorded, and a thorough neurosensory examination should be performed as soon as the local anesthesia effect is lost.¹⁷ Results of the examination, as well as the patient's description of the altered sensation, must be recorded throughout follow-up visits. Events that can lead clinicians to suspect nerve injury include pain or altered sensation during drilling or implant placement, slippage of the drill or implant deeper than planned, and the presence of excessive bleeding, especially if nerve proximity is suspected.

Patients may complain of altered sensation even though clinical procedures were uneventful. Management of the problem will depend on the cause of the IAN injury. As mentioned earlier, nerve injury can occur for many reasons. Radiographs must be taken to confirm whether it has been caused by the implant. If the implant is impinging on the nerve, it should be removed or at least unscrewed a few threads to relieve the pressure on the nerve; this is why we

recommend using an implant that can be "unscrewed" after placement. Whichever the clinician decides to do, he or she must do it as soon as possible to prevent or minimize permanent nerve damage.²³ If the implant causing the problem is already osseointegrated, it can be removed by a trephine drill. As an alternative, an apicoectomy of the implant can be done, if feasible.²⁴

Clinicians might face some instances of altered sensation wherein the implant does not appear to be impinging on the nerve. In such a case, nerve injury may have occurred during drilling. Such a scenario should be strongly suspected if the implant is very close to the IAN canal. Other less frequent causes include local anesthesia or aggressive retraction of the buccal flap.

To control inflammatory reactions in the injured nerve, a course of steroids can be prescribed. An alternative would be a large dose of nonsteroidal anti-inflammatory drugs (eg, 800 mg ibuprofen) 3 times daily for 3 weeks. If the situation improves, the clinician can prescribe another course of anti-inflammatory drugs.¹⁷ Perceptions of pain and temperature are usually the first 2 sensations to recover, whereas other sensations may take longer.²⁵

Many patients respond well to this line of treatment. Any improvement in the patient's condition should be recorded, along with results of a neurosensory examination and the patient's description. If the condition fails to improve within 2 months, referral to a microneurosurgeon is indicated. Early referral will allow for early management before distant degeneration of the nerve takes place.¹⁷ This degeneration usually occurs within 4–6 months of nerve injury.^{26–28} This is the reason why many authors recommend that microsurgery be performed within the first months after injury.²⁵

Strauss et al²⁵ concluded that 50% of the patients who underwent microsurgical repair of the IAN reported significant improvement,

42.9% reported slight improvement, and only 7.1% reported no improvement. They also reported that highly significant improvements were achieved after 1 year of microsurgical intervention.

CONCLUSIONS

One of the serious complications of posterior mandibular implant placement is IAN injury. Proper understanding of the involved anatomy, the surgical procedures, and implant systems—along with proper treatment planning—will reduce the chances of such an unpleasant complication. If nerve injury occurs, early and proper management is the key to maximizing the chances of recovery.

ABBREVIATIONS

CT: computerized tomography

IAN: inferior alveolar nerve

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