Injury to the Inferior Alveolar Nerve During Implant Placement: A Formula for Protection of the Patient and Clinician

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This article concerns the problem of nerve damage associated with implant placement in the posterior mandible. The causes are discussed, with particular emphasis on intrusion of the drill or implant into the nerve canal. Recommendations are made to help the practitioner avoid this too-common complication. INT J ORAL MAXILLOFAC IMPLANTS 2004;19:731–734

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Unintentional injury to the inferior alveolar nerve (IAN) during implant placement in the posterior mandible is important to the patient, to the clinician, and ultimately, to the reputation of the dental profession. For the patient, nerve damage can have results ranging from mild paresthesia to complete anesthesia or even disabling dysesthesia. For the clinician, the results are remorse and often, a lawsuit. Collectively the profession suffers a loss of trust and respect when these events occur. There are indications from several sources that these complications are more frequent than expected. Reports in the literature on the incidence of such complications have been received with deep concern.[1–4] Malpractice insurance carriers complain that this injury is common and difficult and expensive to defend. The seasoned clinicians who serve as expert witnesses (whether for the defendant or the plaintiff) are aware that these lawsuits arise far too often.

To avoid injury to the IAN, some authors have advocated using local anesthetics as infiltration agents only, rather than as nerve blocks, to leave the patient with some sensation.[5] They argue that that it would be beneficial if the patient were aware of the approach of the drill and implant as it neared the canal. In an attempt to lessen the incidence of damage to the IAN, other researchers have developed computer-based navigational systems for drilling in the posterior mandible.[6] So far the success of this strategy seems limited. Other clinicians have devised nerve avoidance tactics, such as slanting the implants in the posterior mandible so that they incline downward and laterally from the crestal cortical bone to engage the buccal cortical plate at a lower level. These have been termed "transverse alveolar implants."[7] The frequency of lawsuits, together with the multiple strategies to avoid the nerve, indicate that this problem is widespread and worthy of attention.

There are many ways in which the IAN may be damaged during the course of implant surgery. Accidental intraneural injection, traction on the mental nerve in a reflected flap, compression of the nerve by an implant intruding into the canal, or penetration by the drill preceding implant placement can all damage the IAN. It seems, however, that the most severe and lasting injuries are caused by the drill, and indeed most practitioners eventually learn by experience that unintentional overpenetration of the

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Fig 1a Roots of mandibular left first molar prior to removal.

Fig 1b An immediately placed mesial implant penetrates the canal.

Fig 1c A press-fit implant placed through the inferior alveolar neurovascular canal, which resulted in nerve dysfunction.

drill can occur very easily. The crestal cortical bone resists the drill, but as soon as the drill tip penetrates into the spongiosa, that resistance suddenly falls, and unless the surgeon has excellent control, the drill may damage the neurovascular bundle.

This situation has been studied by the author in fresh human cadaver mandibles. Deliberate penetration of the drill through the canal was performed under radiologic control, and the jaw was then fixed, sectioned and stained to show the degree of injury to the nerve. As expected, the nerve showed extreme particulation, and the circumstances were not conducive to spontaneous regeneration compared with a clean surgical trans-section.

Many examples could be shown from medicolegal cases, but 2 will suffice.

- **Case 1:** A female patient underwent extraction of the mandibular left first molar (Fig 1a). Two implants were immediately placed, one into each of the root sockets (Fig 1b). The medial implant was sunk much too deeply, probably because as an immediate implant it lacked the support of the crestal cortex that would normally act as a "stop" for the flared neck of the implant. As a result, the patient had paresthesia of the lip and chin. Although the offending implant was later exchanged for a shorter one, the patient's symptoms persisted.
- **Case 2:** A patient had a press-fit implant placed in the left mandible (Fig 1c). The implant extended into the nerve canal; nerve dysfunction followed.

Experience with numerous such cases leads one to the conclusion that some clinicians, despite training in anatomy and despite the publication of articles dealing with the problem of accurately locating the position of the inferior alveolar neurovascular canal,[8,9] do not fully understand the various factors that influence the results. For example, one should be aware of the variation in the course of the IAN as it runs through the jaw.[10] In some patients, the canal rises gently but progressively as it is traced backward from the mental foramen region to the lingula, in others it rises very steeply, and in yet others it hangs down in a catenary fashion, allowing more room for implants above the canal (Figs 2a to 2c).

Many clinicians rely on panoramic radiography. The limitations and pitfalls of panoramic radiography have been described by Serman[11] in a pertinent article. Attention must be paid to the overall direction of the x-ray beam, and the buccolingual position of the canal within the jaw alters the height of bone above the canal that appears on film to be available for implantation (Fig 3a). Furthermore, asymmetry of the crestal bone, when pronounced, can also mislead the clinician regarding the amount of bone available (Fig 3b). In some patients, there may be a thin ridge of bone at the crest that will project onto the panoramic film but which in practice may be useless for implant

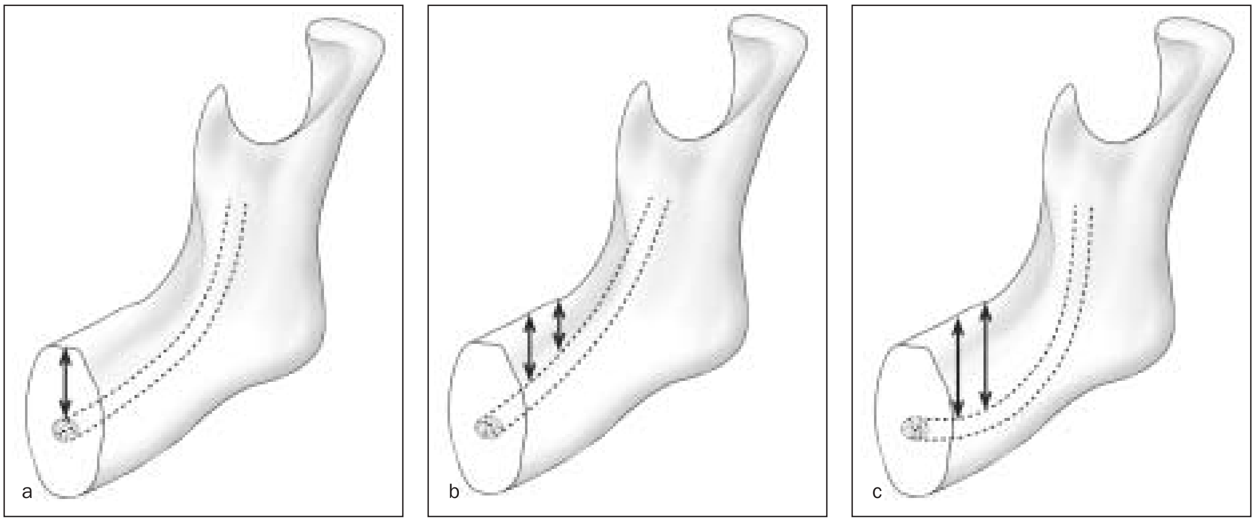

Fig 2 Variations in the course of the IAN as it runs through the mandible: *(a)* A gentle, progressive curve rising from anterior to posterior; *(b)* a steep ascent from anterior to posterior; and *(c)* a catenary-like canal. These variations affect the height of bone available for implants.

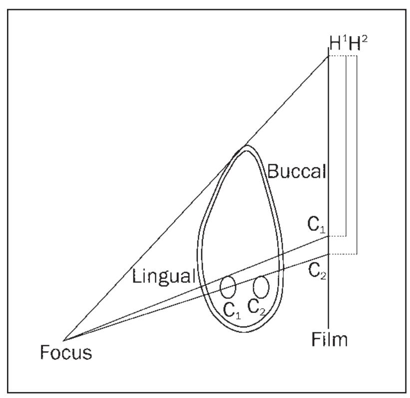

Fig 3a The buccolingual position of the inferior alveolar canal influences the apparent amount of bone available for implant accommodation above the inferior alveolar canal, as viewed in a panoramic radiograph. C_1 and C_2 = positions of the canal; H_1 and H_2 = the amount of bone above the canal as seen in the panoramic radiograph.

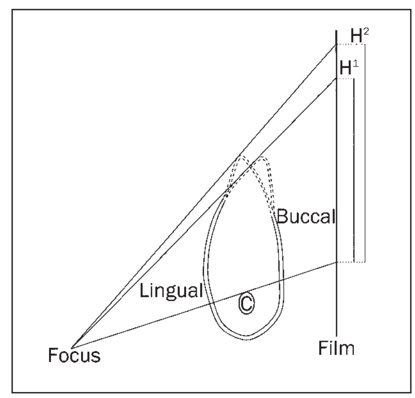

Fig 3b Asymmetry of crestal bone influences the height of bone apparently available for implant accommodation above the canal, as seen on the panoramic film.

accommodation unless a bone augmentation procedure is used. This crestal ridge of relatively useless bone must be taken into account. The magnification factor of an individual panoramic machine must be known and factored into the calculation of the permissible implant length. Finally, it is prudent to allow for a "safety zone," a small space between the tip of the implant (or the preceding drill) and the canal.

If H is the height of bone *apparently* available above the canal on the panoramic film, c is the height of "useless" bone at the crest, s is the safety zone (for this example, a safety zone of 2 mm will be used), m is the magnification factor (eg, if there is 25% magnification, m would be $\frac{5}{4}$), and L is the permissible implant length,

$$L = \frac{H}{M} - c - s$$

For example, if H were 15 mm measured on a panoramic radiograph, c = 2 mm, s = 2 mm, and m = $\frac{5}{4}$, an implant 8 mm long could be placed. If c were 0, then L would be 10 mm.

It should be noted that where a large mandibular torus is present it may project significantly to the lingual side of the mandibular body, and its shadow will project upward onto the film, giving a misleading impression of the available bone height (Fig 4). Clinicians should therefore evaluate the crestal bony anatomy and be prepared to make adjustments as necessary.

DISCUSSION

Schwarz and colleagues[12] advised that "the walls of the mandibular canal are frequently dense cortical bone and with care, the cortical lid of the mandibular canal can be used for anchoring the 'apical' end of the fixture." That advice may be ill-conceived and dangerous. The anchorage of an implant tip in the cortical bone of the roof of the canal is risky.

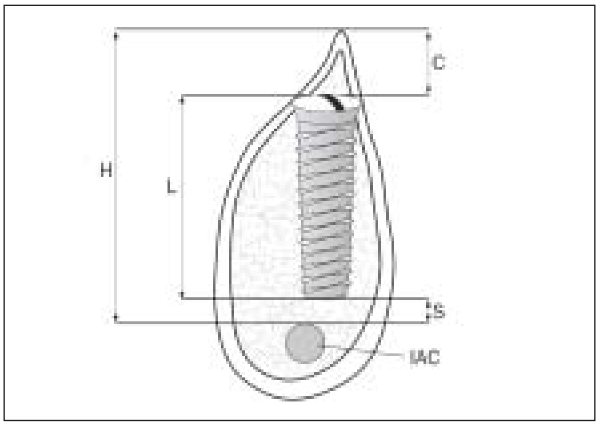

Fig 4 Calculating the permissible height of an implant in the posterior mandible: H = height of bone apparently available for implant accommodation above the IAC as seen on the panoramic radiograph; c = crestal bone too thin for implant accommodation; L = implant length permissible; s = safety zone between the implant site and the inferior alveolar canal; IAC = a cross section of canal; m = magnification factor of the panoramic x-ray machine (eg, if magnification is 25%, m = 5/4).

What other precautions can the clinician take? At one time Nobel Biocare (then known as Nobelpharma) produced metal drill guards that could be fitted over the bur to prevent accidental overpenetration of the bone such as has been described. These are apparently no longer available. Another firm, 3i/Implant Innovations, makes plastic drill stops intended to serve the same purpose. The inventive clinician can design his or her own to suit each case from various forms of readily available plastic tubing.

Some clinicians do not appreciate how easily accidental overpenetration by a drill can occur. Some do not know their own machine's magnification factor. Others naively assume that the use of a transparent overlay template is sufficient to calculate the implant length permissible, but the template does not provide for a safety zone, nor does it take into account details of crestal bony anatomy. Apparently, few clinicians use a drill guard; indeed, many appear not to know about them.

On the basis of many years of experience in these cases, the following recommendations are made:

- Be sure to include nerve injury as an item in the informed consent document.
- Measure the radiograph with care.
- Apply the correct magnification factor.
- Consider the bony crestal anatomy:
  - If the ridge is thin buccolingually, is this useless bone or will an augmentation procedure be done?
  - Is the buccolingual position of the crestal peak of bone influencing the measurement of available bone?
- Consider the buccolingual position of the nerve canal.
- Use coronal true-size tomograms where needed.
- Allow a 1- to 2-mm safety zone.
- Use a drill guard.
- Take care with countersinking not to lose support of the crestal cortical bone.
- Use the aforementioned formula to calculate implant length.
- Keep the radiograph and the calculation in the patient's chart as powerful evidence of meticulous patient care.

The above recommendations are offered in the hope that study of previous mistakes will lessen the chance that those same errors will be repeated.

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