Anatomical study: the potential movability of the inferior alveolar nerve

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Objective. Nerve repair and repositioning are procedures for treating and avoiding injury to the inferior alveolar nerve during oral and maxillofacial surgery. The present study aimed to examine how the mobility of the inferior alveolar neurovascular bundle (IAB) changes with or without removing the bone around the mental foramen (MF).

Study Design. Six fresh-frozen cadavers (11 sides) were dissected in this study. Osteotomy in the buccal cortical bone was performed from 5 mm posterior to the MF to the distal edge of the second molar with a high-speed drill and osteotome. Next, the distance from the lateral surface of the buccal cortical bone to the retracted IAB was measured with and without removing the bone around the MF.

Results. The distance from the lateral surface of the buccal cortical bone to the retracted IAB without removing the bone around the MF was 0 mm on all sides. After removing the bone, the mean distance changed by 4.71 ± 1.41 mm (range 2.83−7.90). There was no statistically significant difference between the right and left sides.

Conclusions. The results of this study support removing the bone around the MF for increased mobility of the IAB. (Oral Surg Oral Med Oral Pathol Oral Radiol 2019;128:353−356)

The inferior alveolar nerve (IAN) is one of the branches from the mandibular division of the trigeminal nerve. The IAN descends in the infratemporal fossa and gives rise to the nerve to the mylohyoid just before entering the mandibular foramen. The IAN runs together with the inferior alveolar vessels in the mandibular canal, that is, the inferior alveolar neurovascular bundle (IAB), and emerges from the mental foramen (MF), which exists below the premolars. The IAN gives off the incisive branch just before exiting the MF. The mandibular canal often has related accessory canals that connect with accessory foramina on the surface of the mandible (e.g., lingual, retromolar, and accessory mental foramina).[1−3]

Injury to the IAN is commonly induced by oral and maxillofacial surgery[4] (e.g., lower third molar removal,[5−7] mandible fractures,[8] orthognathic surgery,[9−11] removal of benign and malignant tumors,[4] dental implant placement,[12] IAN block,[13] and endodontic treatment).[14,15] IAN injury can affect a patient's quality of life.[16] Microsurgical nerve repair can be used for treating nerve transection, lack of improvement of sensory function, severe pain caused by nerve entrapment or neuroma formation, presence of a foreign body, and exacerbation of hypoesthesia or dysesthesia.[17] However, IAN repositioning, including IAN transposition (IANT) and lateralization (IANL) can be used to avoid injury to the IAN.[18] Space to work is limited, and the movability of the IAN inside the mandible is insufficient during these procedures. Surgeons empirically know that the mobility of the IAN can change when the bone around the MF is removed.[19,20] This might be of benefit to surgeons in repairing the IAN with autologous graft or even repairing with direct end-to-end suturing. To our knowledge, there is no study on the changes in the mobility of the IAN with or without removing the bone around the MF. Therefore, this study aims to quantitate the movability of the IAB before and after removing the bone around the MF.

MATERIALS AND METHODS

Eleven sides from 6 fresh-frozen cadavers (5 Caucasian, 1 Asian) were used for this study. The specimens were derived from 2 males and 4 females, with age at death ranging from 57 to 91 years (average age 80.33 ± 11.18 years). Three dentulous and 3 edentulous mandibles were used. The mucosal incision was made in the alveolar ridge (when the mandible had no teeth in this area), or a marginal incision was made from the

Statement of Clinical Relevance

Nerve repair and repositioning are procedures for treating and avoiding injury to the inferior alveolar nerve during oral and maxillofacial surgery, and quantitative knowledge of its mobility can be important in the use of these methods.

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Received for publication Jan 22, 2019; accepted for publication Mar 27, 2019.

2212-4403/$-see front matter
https://doi.org/10.1016/j.oooo.2019.03.014

lower incisors to the retromolar area, and the vertical incision was made into the canine area. The periosteum was elevated laterally to expose the buccal cortical bone of the mandible. Then, a bundle of the mental nerve and vessels emerging from the MF was identified and preserved. The buccal cortical bone was removed en bloc from 5 mm posterior to the MF to the distal edge of the second molar with a high-speed drill (Medtronic, Minneapolis, MN) and osteotome. After removing the buccal cortical bone, the cancellous bone around the IAB was removed with a curette and gently retracted laterally. The horizontal distance from the lateral surface of the cortical bone to the retracted IAB (Distance A) was measured. When the IAB was retracted and did not cross the lateral surface of the cortical bone, distance A was recorded as 0 mm. Subsequently, the bone around the MF was removed without cutting the incisive branch and the distance from the lateral surface of the cortical bone to the further retracted IAB (distance B) was measured (Figure 1). All measurements used a microcaliper (Mitutoyo, Kanagawa, Japan).

All quantitative measurements were shown as the mean ± standard deviation. One-way analysis of variance was used to compare data with Scheffé's post hoc test and Fisher's exact test. Statistical significance configured at $P < .05$. Approval by our ethical committee was not required because this was a cadaveric study. The study was conducted in accordance with the tenets of the Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013).

Table I. Difference of distance B between both sides

	Mean (mm)	Range	P value
Right (n = 5)	3.72 ± 0.64	2.83−4.81	.17
Left (n = 6)	5.00 ± 1.64	2.55−7.90	

RESULTS

On all sides (11 of 11), the incisive branch was preserved when the bone around the MF was removed. Distance A was 0 mm on all sides. The mean of distance B was 4.42 ± 1.44 mm (range 2.83−7.90 mm) on all sides. The means of distance B on the right (n = 5) and left (n = 6) sides were 3.72 ± 0.64 mm (range 2.83−4.81 mm) and 5.00 ± 1.64 mm (range 2.55−7.90 mm), respectively (Table I). The means of distance B on the dentulous (n = 5) and edentulous (n = 6) sides were 4.62 ± 1.75 mm (range 2.83−7.90 mm) and 4.25 ± 1.07 mm (range 2.55−4.81 mm), respectively (Table II). There was no significant difference between sides ($P > .05$). There was also no significant difference between dentulous and edentulous specimens ($P > .05$). No previous injury or anatomic variations of the IAN was observed on any side.

DISCUSSION

Various etiologies can result in IAN injury and these can affect a patient's quality of life.[16] IAN injury may also lead to complaints from patients and to medicolegal issues.[21] A small percentage of patients have permanent neurosensory dysfunction, although most recover spontaneously.[4] The most common etiology of

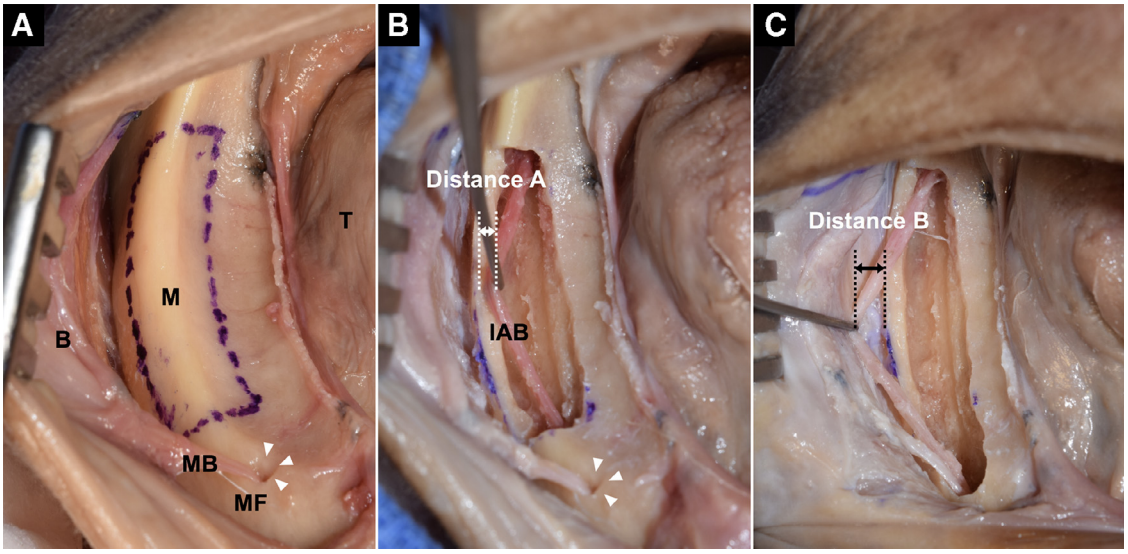

Fig. 1. Exposure of the right inferior alveolar neurovascular bundle (IAB) in a fresh cadaver.**(A)** Setting of the bone window. **(B)** Retracting the IAB without removing the bone around the mental foramen *(arrowhead)*. White arrows showing distance A. **(C)** Retracting the IAB after removing the bone around the MF. Black arrows showing distance B. *B,* buccal; *IAB,* inferior alveolar neurovascular bundle; *M,* mandible; *MB,* mental neurovascular bundle, *MF,* mental foramen.

Table II. Difference of distance B between dentulous and edentulous sides

	Mean (mm)	Range	P value
Dentulous (n = 5)	4.62 ± 1.75	2.83−7.90	.71
Edentulous (n = 6)	4.25 ± 1.07	2.55−4.81	

IAN injury is the removal of the lower third molar, and implant placement in the posterior part of the mandible also has a high risk of IAN injury.[12,22−25] Mandible fractures,[8] orthognathic surgery,[9−11] removal of tumors,[4] IAN block,[13] and endodontic treatment,[14,15] can also lead to nerve injury. IANL and IANT are alternative approaches for avoiding IAN injury.[26−31] In contrast, nerve repair using microsurgical techniques is used for patients with irreversible nerve injury (i.e., nerve transection, sensory disturbance lasting greater than 3 months, development of pain induced by nerve entrapment or neuroma, presence of a foreign body, aggravation of hypoesthesia or dysesthesia, and intolerable hypoesthesia).[17] Surgeons perform these procedures in a limited space, and these techniques may be difficult for inexperienced surgeons.[26] Therefore, the use of ultrasonic bone-cutting instruments, such as PIEZOSURGERY, which can selectively cut bone and prevent injury to adjacent soft tissues,[11] is recommended for these procedures.[30,32] Thus, difficulty of IAN surgery, including nerve repair, IANT, and IANL, could be influenced by the mobility of the IAN.

Removal of the bone around the MF without resection of the incisive branch is challenging, and the incisive branch may incidentally be resected during the procedure. Because the incisive branch innervates the first premolar, canines and incisors, and the associated labial and buccal gingivae,[33] its resection can induce sensory disturbance in these regions. Although some studies report that the intentional resection of the incisive branch did not result in any neurologic disorder,[19,34] acute bleeding resulting from injury of the incisive branch has been reported.[35] The clinical importance of the incisive branch depends on the patient having incisor teeth or not. It might be difficult to predict the postoperative neurosensory disturbance, but it is easy to prevent the bleeding when the surgeon observes a large incisive branch on cone beam computed tomography.

Surgeons do not have quantitative knowledge of the mobility of the IAN but empirically know that this increases with removing the bone around the MF.[19,20] This study clarified that the lateral mobility of the IAB was significantly increased by removing the bone around the MF without excising the incisive branch. This result may also provide important information for achieving IAN repair without tension. Suturing with lack of tension is essential for successful nerve repair.[36,37] Tension greater than 25 G makes nerve regeneration less likely. These conditions can lead to inhibition of nerve continuity and conductivity.[38,39] As a result of this study, removal of the bone around the MF can be used as a source of tension relief when surgeons perform nerve repair of the IAN.

CONCLUSIONS

This study clarified and quantitated that removing the bone around the MF without resecting the incisive branch increases IAB mobility. Additionally, such a maneuver might prevent sensory disturbance in the distribution of the incisive branch.

ACKNOWLEDGMENT

The authors thank those who donated their bodies for anatomic research.

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