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ORIGINAL ARTICLE

A new and simplified extraoral approach for inferior alveolar nerve block: a cadaveric study and clinical case reports

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Abstract

Purpose Inferior alveolar nerve (IAN) and lingual nerve (LN) blocks are commonly performed using the intraoral landmark techniques. However, these methods have a risk of unanticipated nerve and arterial injury or a higher failure rate. We developed a novel extraoral approach for the IAN and LN blocks, the "inferior alveolar nerve block mandibular angle approach (IANB-MA)," using ultrasound guidance. The mechanism of action of this nerve block was examined anatomically, and its clinical feasibility was reported.

Methods We performed the IANB-MA on four cadavers using different dye volumes (2, 4, 6 and 8 mL). The ultrasound probe was placed on the lower edge of the mandibula of each cadaver, and the needle was advanced to the mandibular inner surface. Blue acrylic paint solution was injected, and its spread was evaluated by dissection.

Results Our study showed that the medial pterygoid muscle fascia was stained in all cadavers. The dye reached the LN consistently, and the IAN was stained with higher volumes (6 mL and 8 mL). The pterygomandibular space was filled with 6 mL and 8 mL of the dye. The IANB-MA successfully reduced pain in three patients with trigeminal neuralgia, tongue or jaw pain.

Conclusions The IANB-MA is a novel ultrasound-guided approach to the IAN and the LN. The clinical feasibility and effectiveness of this technique were confirmed in our patients. It may be a good alternative analgesic approach to other conventional approaches.

Keywords Mandibula · Ultrasound · Medial pterygoid muscle · Neuropathic pain · Facial pain · Trigeminal neuralgia

Introduction

The inferior alveolar nerve (IAN) and lingual nerve (LN) are branches of the mandibular nerve, the third branch of the trigeminal nerve. They supply sensory coverage on the mandible, mandibular teeth, a part of the tongue, and the floor of the mouth. IAN and LN blocks are commonly performed in dental surgery using intraoral landmark methods [1, 2]. These techniques block the IAN and the LN near the mandibular foramen. However, intraoral approaches carry some risks, including nerve and vascular injury, with a higher failure rate of 20–47% [1].

We developed a novel ultrasound-guided approach for IAN and LN blocks: the inferior alveolar nerve block mandibular angle approach (IANB-MA). In this technique, the needle is inserted through the mandibular angle and reaches the medial side of the mandible. We performed the block on four cadavers and evaluated the dye spread. We describe this technique and then clinical application in three patients in the case reports below.

Materials and methods

This cadaveric study was reviewed and approved by the Kyorin University Ethical Review Board (Reception No. 2290, approved on December 7, 2023). Written informed consent for the publication of this case report and

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accompanying images were obtained from the patients. All nerve blocks were performed by the attending anesthesiologist and pain physician (K.W).

Cadaveric study

To investigate the anatomical structure surrounding the IAN and the LN, we used four cadavers (an 86-year-old woman, an 83-year-old man, a 98-year-old man, and a 101-year-old woman) fixed with N-vinyl-2-pyrrolidone which keeps the tissue soft and pliable [3].

Anatomy surrounding the IAN and the LN

The IAN and LN branch off from the mandibular nerve and descend through the pterygomandibular space (PMS). The PMS is surrounded by the masseter, temporal, lateral pterygoid, and medial pterygoid muscles. The IAN and LN continue to descend medially toward the mandible through the PMS. The IAN, along with the IA artery and vein, enters the mandibular foramen. The outer side of the medial pterygoid muscle (MPM) faces the IAN and the LN (Fig. 1). The MPM inserts along the medial surface of the mandibular angle and is called the pterygoid tuberosity. The IAN, together with the inferior alveolar artery, enters the mandibular foramen.

Anatomical evaluation and technique of the IANB-MA

The ultrasound machine used was a SonoSite SII (FUJIFILM Inc., Tokyo, Japan), and the ultrasound probe was a L38/13-6 (FUJIFILM Sonosite Inc., WA, USA). The needle used for the nerve block was a nerve block needle (Stimplex Ultra 360, size 22G, length 50 mm, B. Braun, Melsungen, Germany).

In this study, the IANB-MA was performed on the four cadavers to confirm the spread of the blue dye solution in four different volumes (2, 4, 6, and 8 mL).

The ultrasound probe was placed at the lower edge of the cadaver's mandibular angle (Fig. 2A). The proximal end of the probe was rotated inward and tilted outward to observe the medial aspect of the mandible (Fig. 2B). The needle was advanced past the pterygoid tuberosity until it hit the medial surface of the mandible. Dissection was performed within 20 min of injecting the dye solution.

Results

Cadaveric study

Dissection revealed that the dye had spread along the fascia of the MPM. After injecting 2 mL of dye, staining of the MPM fascia toward the IAN was observed. The LN was thinly stained (Fig. 3A). Using 4 mL, the entire MPM fascia was stained from its origin to insertion (Fig. 3B). The LN was stained. However, no staining of the IAN was detected. At the 6 mL injection, the PMS was filled with the dye. The IAN was partially and thinly stained (Fig. 3C). At the 8 mL injection, the fascia covering the IA neurovascular bundle was stained. The thinly stained IAN was observed after removing the connective tissue surrounding the bundle (Fig. 3D).

Case reports

Case 1: a 50-year-old woman underwent extraction of an impacted wisdom tooth in her left lower mandible at a dental clinic 2 years ago. She experienced severe radiating pain in the mandible while receiving an IAN block for the procedure. Since then, she has suffered from sudden shooting

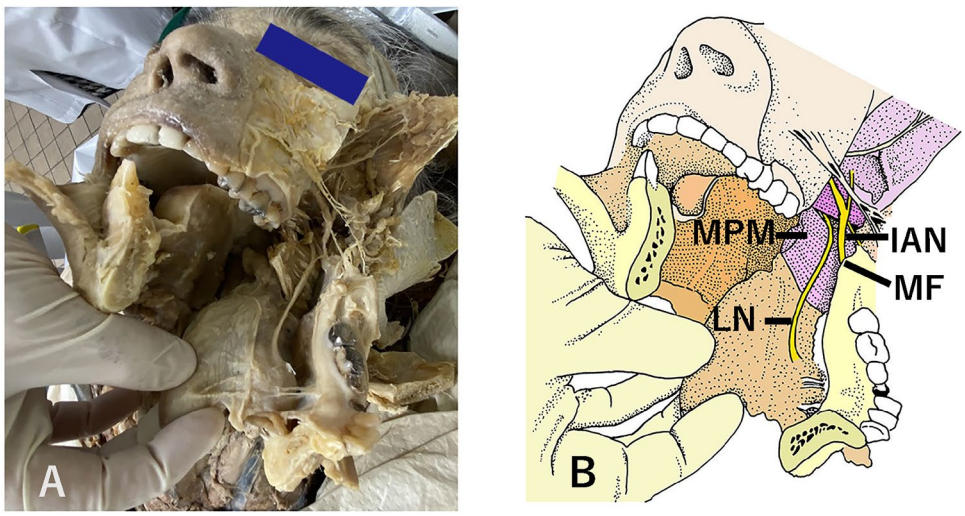

Fig. 1 IAN and LN and their surrounding structures. **A** Anatomy of the pterygomandibular space. **B** Schematic illustration of photo A, illustration of the inferior alveolar nerve and the lingual nerve positional relationship with the medial pterygoid muscle. *IAN* inferior alveolar nerve, *MPM* medial pterygoid muscle, *LN* lingual nerve, *MF* mandibular foramen

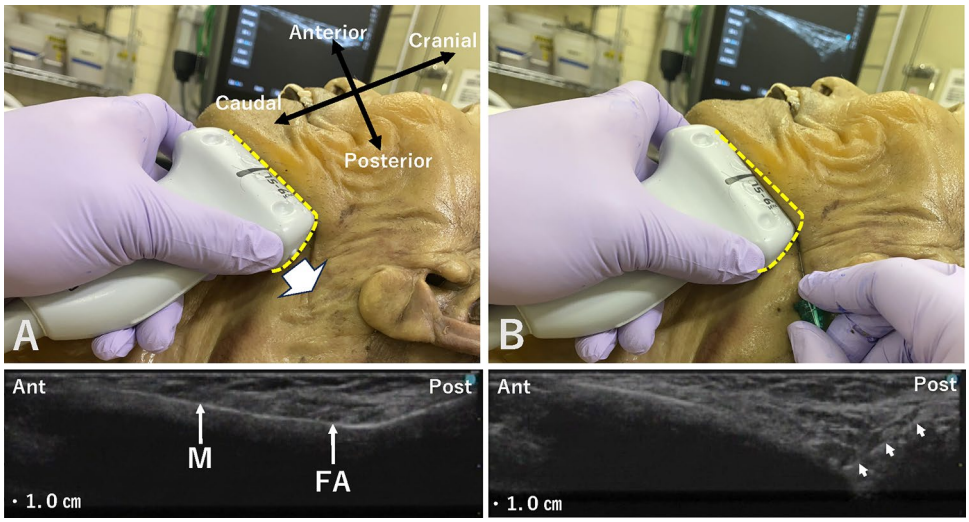

Fig. 2 Technique of the IANB-MA. **A** The ultrasound probe is placed at the lower edge of the mandibular angle of the cadaver. The yellow line indicates the probe's position in contact with the mandible. **B** The proximal end of the probe is rotated inward and tilted outward to observe the medial aspect of the mandible (the yellow dashed line indicates the position of the probe contacting the mandible in **A**). The pterygoid tuberosity, anatomically the insertion of the medial pterygoid muscle, is easily recognized by its rugged surface. The needle is advanced past the pterygoid tuberosity until it hits the medial surface of the mandible. Arrowheads (white) indicate the needle. *M* mandible, *FA* facial artery

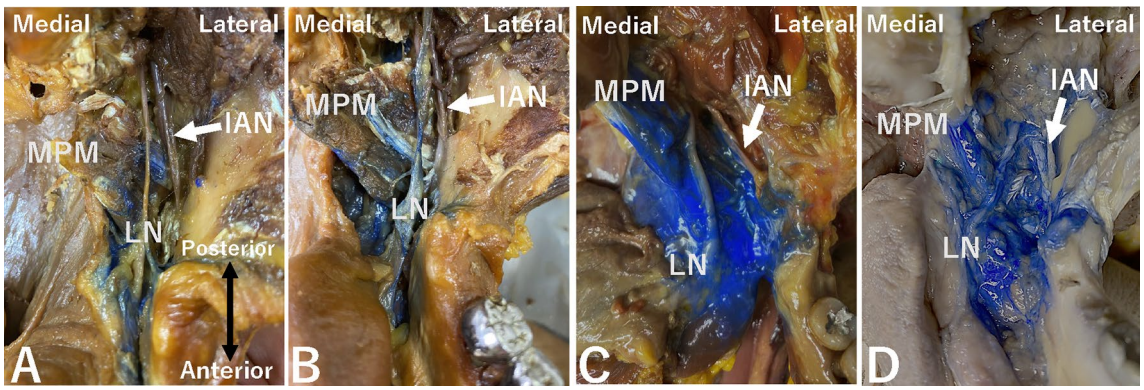

Fig. 3 Dissection of the pterygomandibular space. **A** Dissection after injecting 2 mL of dye. The MPM fascia is stained. The LN is thinly stained. **B** Dissection after injecting 4 mL of dye. The MPM fascia is stained from the origin to the insertion. The LN is stained with dye; however, the IAN is not stained. **C** Dissection after injecting 6 mL of dye. The pterygomandibular space is filled with a dye solution. The IAN is partially thinly stained. **D** Dissection after injecting 8 mL of dye. The IA neurovascular bundle, which consists of the IAN, artery, and vein, is stained. To confirm the staining of the IAN, the covering connective tissue of the bundle was removed, and the IAN was stained. *IAN* inferior alveolar nerve, *MPM* medial pterygoid muscle, *LN* lingual nerve

pain and persistent paresthesia in the left mandible and lower teeth. She was diagnosed with trigeminal neuralgia and treated with carbamazepine and pregabalin. However, her symptoms continued to worsen, and her pain spread within her head. She was then referred to our pain clinic for treatment. She had difficulty opening her mouth wide due to pain. Hence, the IANB-MA was performed with 2 mL of 0.5% levobupivacaine (Fig. 4). After the nerve block, the shooting pain disappeared, and the numeric pain rating scale (NPRS) decreased from 9 to 2 for 2 days. No obvious hypoesthesia was observed in the lower jaw after the nerve block. The nerve block was repeated once a week for 2 months until her pain could be controlled with oral medications.

Case 2: an 80-year-old woman had a right mastectomy for breast cancer 20 years ago. Three years ago, she was diagnosed with bone and liver metastases, and chemotherapy was initiated. Due to chemotherapy with denosumab, she developed left-sided osteonecrosis of the jaw. Her oral surgeon prescribed controlled-release oxycodone (10 mg/day), immediate-release oxycodone (2.5 mg per dose), and pregabalin for pain and zolpidem for sleep. However, her pain did not abate using these medications. An IANB-MA

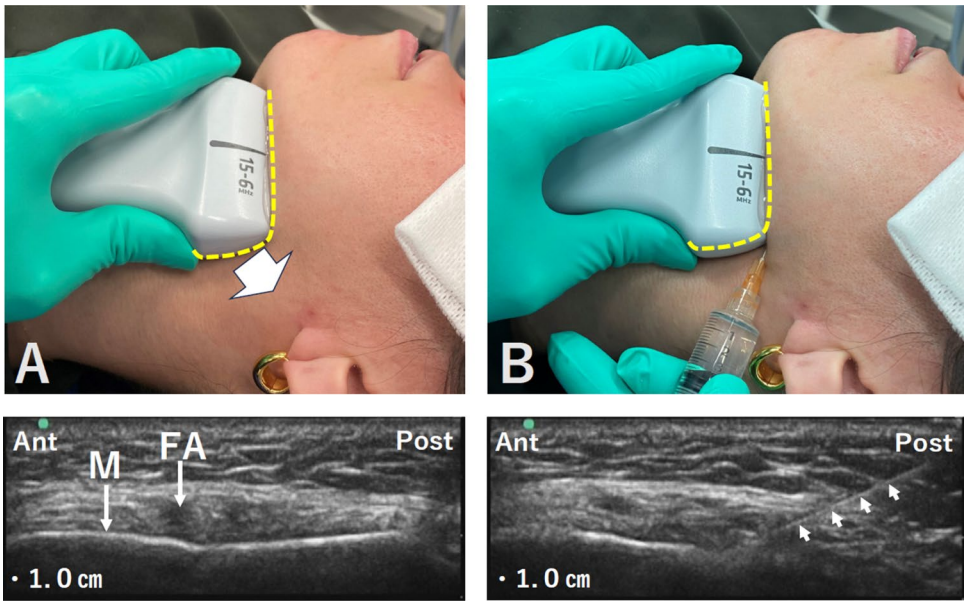

Fig. 4 The IANB-MA for trigeminal neuralgia (case 1). **A** The ultrasound probe is placed at the lower edge of the patient's mandibular angle. The yellow dashed line indicates the probe's position in contact with the mandible. **B** The proximal end of the probe is rotated inward and tilted outward to observe the medial aspect of the mandible (the yellow dashed line indicates the position of the probe contacting the mandible in **A**). The needle was carefully advanced past the pterygoid tuberosity until it hit the medial surface of the mandible, avoiding injury to the facial artery. Arrowheads (white) indicate the needle; *M* mandible, *FA* facial artery

was performed using 4 mL of 0.5% levobupivacaine. After the nerve block, the patient felt no pain for approximately 1 day, but did experience some hypoesthesia in the tongue. The patient was then treated with an IANB-MA once every 2 weeks. She reported being very satisfied with the nerve block procedure.

Case 3: a 52-year-old woman with a history of liver cirrhosis and thrombocytopenia presented to our pain clinic with oral pain caused by a tongue ulcer. She was being assessed for the possibility of having Behçet's disease because the pain from the ulceration was severe. Despite initiating controlled-release oxycodone (20 mg/day), tramadol (160 mg/day), and pregabalin, the pain was not well controlled. Subsequently, an IANB-MA with 0.5% levobupivacaine (4 mL) and a stellate ganglion block with 1% carbocaine (5 mL) were performed. After approximately 1 day following the nerve blocks, her NPRS decreased from 10 to 3. The patient was able to sleep at night. She expressed an interest in having another nerve block if the pain worsened.

Discussion

In the cadaver studies, dye spread was seen on the surface of the MPM fascia. The MPM fascia was stained with the smallest volume of dye (2 mL). The dye consistently reached the LN. The IAN was stained with higher volumes (6 mL and 8 mL). With 8 mL of dye, the PMS (the space between the MPM and the medial side of the mandible) was filled with dye, and the dye penetrated the connective tissue of the IA bundle and stained the IAN.

A facial artery running inside the mandible was used as an anatomical landmark for needle insertion. The facial artery passes from inside to outside the mandible at 3–3.5 cm forward from the mandibular angle [4]. The width of the MPM is approximately 2–2.5 cm and is attached to the pterygoid tuberosity. To perform a successful nerve block, the needle should be placed on the medial side of the mandible near the mandibular angle, and not pass over the facial artery.

Recently, an ultrasound-guided IAN block involving injection from below the zygomatic arch has been reported to be effective for postoperative analgesia for mandibular fractures. This technique is called the ultrasound-guided zygomatic arch approach [5, 6]. This approach is expected to be more accurate than the traditional intraoral approach; however, it requires a high degree of technical skill due to the deep block. Furthermore, hemostasis is difficult if the maxillary or superficial temporal arteries are accidentally injured because manual compression cannot be performed. Also, the patient must keep the mouth wide open during the procedure to maintain a good ultrasound view. The benefits of the IANB-MA are (1) it is a superficial block, and thus technically easier, (2) it can be performed without opening of the month, which has a significant advantage if a patient cannot open the mouth due to pain, radiation treatment, trismus, or structural issues. This technique may also be a good choice when an intraoral approach fails. However, traumatic mandibular injuries causing PMS tears may preclude its use.

Our patients tolerated the procedure well without any sedation. We did not encounter any complications or side effects. However, like other approaches, potential side effects could be intravascular injection, hematoma, trismus, or infection. Also, while minor and temporary, a puncture site may be visible.

The three case reports show that the IANB-MA was effective in relieving pain with 2 mL and 4 mL of local anesthetic,

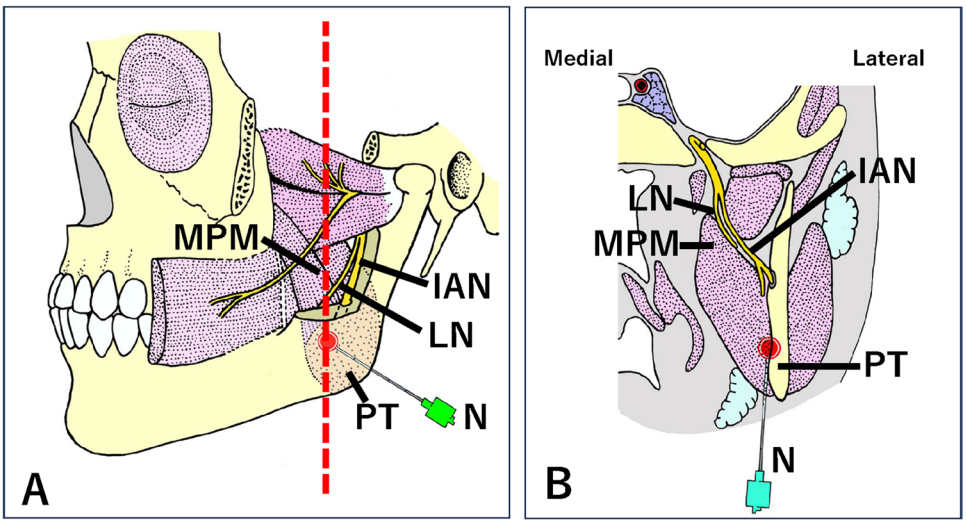

Fig. 5 Illustration of the IANB-MA needle position. Lateral view, **B** coronal view of the red dotted line in **A**. The block needle tip (red dot) is advanced until it contacts the pterygoid tuberosity. Presumably, local anesthetic spreads along the medial pterygoid fascia first, and then to the pterygomandibular space. *IAN* inferior alveolar nerve, *MPM* medial pterygoid muscle, *LN* lingual nerve, *PT* pterygoid tuberosity, *N* block needle

but did not necessarily provide complete anesthesia. This finding may be explained by our cadaveric study; the MPM fascia was stained, but the nerves were not stained or were partially stained at most with lower volumes of dye (2 mL, 4 mL). With higher volumes (6 mL, 8 mL), the PMS was filled with dye, and the nerves were more stained. Since the MPM is inserted into pterygoid tuberosity, dye initially spreads along the MPM fascia, and then spills into the PMS and then reaches the nerves (Fig. 5). Future studies should focus on finding an optimal local anesthetic dose and applying this nerve block for postoperative analgesia.

We developed a novel extraoral approach for the IAN and the LN blocks: the IANB-MA. Based on our cadaveric study and reports from our patients, this block can be easily performed by practitioners not trained in intraoral techniques. This new block potentially addresses various chronic pain conditions in the area of the lower jaw and the mouth.

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Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest All authors have no conflicts of interest.

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