A Cadaveric Study of Ultrasound-Guided Maxillary Nerve Block Via the Pterygopalatine Fossa
A Novel Technique Using the Lateral Pterygoid Plate Approach
Wirinaree Kampitak, MD,* Tanvaa Tansatit, MD, MSc;† and Yasuyuki Shibata, MD, PhD‡

Background and Objectives: This study aimed to describe and assess the accuracy and feasibility of a novel technique for ultrasound-guided maxillary nerve block using the lateral pterygoid plate (LPP) approach via the pterygopalatine fossa (PPF) in a soft cadaveric model.

Methods: Ten soft cadavers were studied. The curved array ultrasound transducer probe was applied over 1 side of the face of the cadavers in the open-mouth posture. It was placed transversely below the zygomatic arch for identifying the border of the maxillary tuberosity and the LPP. We tilted the curve probe from the caudal to the cranial direction until the uppermost part of the PPF was identified. The in-plane needle approach was used from the anterior-to-posterior and lateral-to-medial directions through the fossa, and 3 mL of methylene blue dye was injected.

Results: The spread of injectate after ultrasound-guided maxillary nerve block using the LPP approach was successfully performed in all cadavers as demonstrated by visualized moderate to marked traces of methylene blue within the PPF. No accidental injections in the maxillary arteries or facial nerves were observed.

Conclusions: This cadaveric study suggests that ultrasound-guided maxillary nerve block using the LPP approach via the PPF has a high degree of accuracy and feasibility. Further studies are required to confirm its efficacy and safety for clinical application.

(reg Anesth Pain Med 2018;43: 00-00)

The maxillary nerve block is useful for anesthesia in 3 main areas: the mouth, nose, and medial part of the face. Although local anesthetic infiltration around the surgical site or oral cavity is easier to perform compared with a selective nerve block, it may not be plausible in some situations such as the presence of infection or inflammation at the surgical site. Moreover, surgery that requires multiple injections of local anesthesia may result in severe pain or local anesthetic toxicity due to excessive dosage. Therefore, the maxillary nerve block is preferred over local anesthetic infiltration and can also be used for the diagnostic evaluation of facial pain to determine whether pain is somatic or sympathetic in origin, for permitting anatomic differential neural blockade, and for procedures of neurodestructive using neurolytic agents.

Oral and maxillofacial surgical procedures are frequently conducted under local anesthesia. In order to manage pain, intraoperative intravenous opioids are used, which may result in excessive sedation, respiratory depression, and postoperative nausea and vomiting. These symptoms may cause serious complications and suffering, particularly in patients who undergo intermaxillary fixation during the postoperative period. The use of the maxillary nerve block for head and neck surgery may provide superior pain relief compared with the use of systemic opioids; moreover, it also results in better rehabilitation.

The use of ultrasound guidance for regional anesthesia and mitigation of pain has become increasingly popular because of several advantages, including a favorable safety profile, ease of performance, and the lack of radiation exposure. Not only is it helpful to identify key anatomical structures, but it also allows for optimal needle insertion through visualization of the needle tip during advancement. With regard to head and neck blocks, the use of ultrasound images has been implicated in various superficial to deep nerve blocks. Although trigeminal nerve blockade via the pterygopalatine fossa (PPF) under ultrasound guidance has been described in several reports, the key anatomical landmarks, including the maxilla and lateral pterygoid plate (LPP), on ultrasound imaging remain unclear.

The aim of this study was to evaluate the accuracy and feasibility of a novel technique for selective ultrasound-guided maxillary nerve block using the LPP approach via the PPF in a soft cadaver model.

METHODS

After approval by the institutional review board of Chulalongkorn University, Bangkok, Thailand, and registration with Clinical trials.in.th (TCTR20160303001), 10 soft, well-embalmed cadavers (5 males/5 females) were selected for this study, which was performed in the Department of Anatomy at Chulalongkorn University, Thailand. Informed consent was not necessary for the study. All cadavers were embalmed with a modified Thiel solution, which preserved adequate tissue integrity and flexibility for ultrasound images and surgical procedures. None of the cadavers had any acquired or congenital craniofacial defects, and all exhibited intact superficial facial skin. Each cadaver received 1 injection on either side of the face according to a computer-generated randomization list created by an independent researcher. After opening the cadaver’s mouth using a jaw opener, the head was twisted to face the investigator, against the position of the ultrasound machine.

The maxillary nerve is a sensory branch of the fifth cranial nerve (the trigeminal nerve). It arises from the middle cranial fossa, passes through the foramen rotundum, crosses the PPF and has multiple branches, including the palatine, zygomatic, nasopalatine, superior alveolar, and pharyngeal nerves (Fig. 1A). The PPF is located between the maxillary bone anteriorly and the pterygoid process of the sphenoid bone posteriorly and is inferior to the sphenoid bone.

From the Departments of *Anesthesiology and †Anatomy, King Chulalongkorn Memorial Hospital, The Thai Red Cross Society, and Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand; and ‡Department of Anesthesiology, Nagoya University Hospital, Nagoya, Japan.

Accepted for publication January 15, 2018.

Address correspondence to: Yasuyuki Shibata, MD, PhD, Department of Anesthesiology, Nagoya University Hospital, 65 Tsurumai-cho, Showa-ku, Nagoya 466-8550, Japan (e-mail: yshaiba@tuba.ocn.ne.jp; yshaiba@med.nagoya-u.ac.jp).

This study was supported by the Ratchadapiseksompotch, Faculty of Medicine, Chulalongkorn University (grant RA59/075).

The authors declare no conflict of interest.

Copyright © 2018 by American Society of Regional Anesthesia and Pain Medicine
ISSN: 1098-7339
DOI: 10.1097/AAP.0000000000000790
to the orbital apex. It is a bilateral, inverse pyramid-shaped structure and communicates with the infratemporal fossa via the pterygomaxillary fissure (PMF). It also communicates with the infratemporal fossa via the pterygopalatine fossa (PPF) and the maxillary artery. The PMF is a bilateral, inverse pyramid-shaped structure that connects the infratemporal fossa to the orbit. It is a bilateral, inverse pyramid-shaped structure and communicates with the infratemporal fossa via the pterygomaxillary fissure (PMF). It also communicates with the infratemporal fossa via the pterygopalatine fossa (PPF) and the maxillary artery.

RESULTS

The dye injections of ultrasound-guided maxillary nerve blocks using the LPP approach were successfully administered in all 10 cadavers. The MT and LPP were clearly visualized on the ultrasound image as hyperechoic lines. We identified the uppermost part of the PMF at the top level of the LPP (Fig. 2, C and E). In all cadaveric specimens, moderate to marked traces of methylene blue were found within the PPF, staining the maxillary nerve, pterygopalatine ganglion, greater and lesser palatine nerves, and middle and posterior superior alveolar nerves; Fig. 3B. Moreover, we identified methylene blue stains in the infraorbital foramen in 8 cadavers (Fig. 3C).

DISCUSSION

Blockade of the maxillary nerve is generally performed using a paresthesia technique for 3 common approaches for needle injection: the high tuberosity, the greater palatine canal, and the coronoid approaches. The former two require a local injection.
FIGURE 2. The illustrations demonstrate the lateral part of the human skull located with the ultrasound probe (black bar) (A–E) and ultrasonographic visualization of the anatomical landmarks for a maxillary nerve block using the LPP approach via the PPF in a water phantom (A1–E1) and cadaver skull (A2–E2). A, The ultrasound probe was placed below the zygomatic arch in the neutral position of the skull. B, The ultrasound probe was located at the lowermost part of the LPP when the skull's mouth was maximally open. C, The ultrasound probe was placed at the space between the bottom and the top of the LPP (the PMF). D, The ultrasound probe was placed at the skull base. E, The ultrasound probe was located at the uppermost part of the LPP, and the in-plane needle approach was with the needle inserted from the anterior-to-posterior direction into the PPF at this level. CP indicates coronoid process of the mandible; LPM, lateral pterygoid muscle; MC, mandibular condyle; MT, maxillary tuberosity; SB, skull base; TM, temporalis muscle; ZA, zygomatic arch; arrow (blue), continuous hyperechoic line from the border of the MT to the LPP; arrow (red), interrupted hyperechoic line from the border of the MT to the LPP; asterisk (green), the skull base; arrow (pink), the needle pathway.
into areas in the oral cavity, such as the mucobuccal fold and palate. Although the intraoral technique is commonly used, it may be associated with serious complications such as intravascular injection, diplopia, transient ophthalmoplegia, and infraorbital nerve injury. Moreover, these techniques may be difficult to perform under imaging guidance. The coronoid approach may be easier to perform under imaging guidance because the injection point is outside the oral cavity and the maxillary nerve is blocked via the PPF.

Previous studies have demonstrated the usefulness of ultrasound-guided maxillary nerve block. Hafeez et al identified the location and characteristics of the greater palatine foramen and found positive India ink staining within the greater palatine canal and PPF in 44% (7/16) of cadaveric heads that received ultrasound-guided maxillary nerve block. Furthermore, 75% (6/8) and 100% (2/2) of patients received a successful greater palatine nerve block using the greater palatine canal approach under real-time and assisted ultrasound guidance, respectively. Sola et al described ultrasound-guided trigeminal nerve block via the PPF and defined the lateral pterygoid muscle and the maxillary artery as key anatomical structures. However, their findings on the ultrasound view remained unclear. Moreover, their technique was opposite to that used in our study because they held the patient’s mouth in the neutral position and placed the ultrasound probe just below the zygomatic bone, anterior to the condylar process of the mandible and superior to the mandibular notch (Fig. 5C). Therefore, the PPF could not be clearly visualized because it was obscured by the coronoid process of the mandible because of inadequate mouth opening. In addition, different needle advancement including the posterior-to-anterior and lateral-to-medial directions through the lateral pterygoid muscle, anterior to the PPF, and into the PPF was used in their study (Fig. 5C). Thus, their needle pathway poses a risk of passing through several branches of the facial nerve and the parotid gland, possibly resulting in accidental injury of

Several studies have shown the effectiveness of ultrasound guidance for trigeminal nerve block via the PPF. Kim et al demonstrated pain relief after ultrasound-guided trigeminal nerve block via the PPF in a patient with trigeminal neuralgia. However, the ultrasound technique and key anatomical landmarks on the ultrasound view were not clearly defined. Nader et al described ultrasound-guided trigeminal nerve block via the PPF and defined the lateral pterygoid muscle and the maxillary artery as key anatomical structures. However, their findings on the ultrasound view remained unclear. Moreover, their technique was opposite to that used in our study because they held the patient’s mouth in the neutral position and placed the ultrasound probe just below the zygomatic bone, anterior to the condylar process of the mandible and superior to the mandibular notch (Fig. 5C). Therefore, the PPF could not be clearly visualized because it was obscured by the coronoid process of the mandible because of inadequate mouth opening. In addition, different needle advancement including the posterior-to-anterior and lateral-to-medial directions through the lateral pterygoid muscle, anterior to the LPP, and into the PPF was used in their study (Fig. 5C). Thus, their needle pathway poses a risk of passing through several branches of the facial nerve and the parotid gland, possibly resulting in accidental injury of

![FIGURE 3.](image-url)
these structures. Furthermore, with their technique, the tip of the needle was placed just above the LPP. Therefore, anesthetic drugs could not adequately penetrate through the PPF, as demonstrated by visualized methylene blue stain within the buccal fat pad (Fig. 5D).

Our study in soft cadavers showed that ultrasound-guided selective maxillary nerve block is reliable for identifying the boundary of the PMF, the PPF opening, the uppermost part of the LPP, and the needle insertion point. Our technique offers a novel method for maxillary nerve block using the LPP approach via the PPF. The PPF could be clearly visualized on the ultrasound images of all cadaveric specimens because the mouth was kept wide open to separate the coronoid process of the mandible from the LPP and maxilla (Figs. 2B1, B2). We confirmed that further advancement of the needle by 1 to 2 mm from the top of the PPF, which was identified by locating the ultrasound probe from the bottom to the top of the LPP, is the optimal site for maxillary nerve block.\(^2\) Our novel technique can also avoid the parotid duct and facial nerve injury that may occur after maxillary nerve block under fluoroscopy.\(^2\) Moreover, there was no case of intra-arterial injection. Needle insertion at this point may prevent injury to the maxillary artery, which was located underneath the needle pathway in our technique. However, further clinical studies are warranted for identification of the maxillary artery and branches in the PPF using color Doppler ultrasonography and identification of the tip of the needle toward the uppermost part of the PPF.

This study has several limitations. First, the spread of the injectate in a cadaveric model may not be consistent or clinically correlated with the findings in human subject. Second, the infraorbital nerve failed to be stained with methylene blue in 2 cadavers. Therefore, the clinical efficacy of the infraorbital nerve block by our technique needs to be verified by clinical studies. Finally, although the use of ultrasound imaging to assist selective maxillary nerve block is helpful to delineate the surrounding tissues, bony structures, and the PPF, the actual nerves cannot be visualized on ultrasound images. Therefore, a high level of expertise is required for visualization of the needle tip in order to avoid accidental injury to the surrounding structures during the procedure.

Our cadaveric study suggests that selective maxillary nerve block under ultrasound guidance using the LPP approach via the

---

**FIGURE 4.** Dissection of the left side of the face of a cadaveric specimen after ultrasound-guided maxillary nerve block injection with methylene blue. A, The needle injection pathway involves the zygomatic branch of the facial nerve at the superior site and the buccal branch of the facial nerve at the posterior site. B, The parotid duct below the needle injection pathway. C, The maxillary artery below the needle injection pathway. BFN indicates buccal branch of the facial nerve; MA, maxillary artery; MT, maxillary tuberosity; PD, parotid duct; SB, skull base; ZA, zygomatic arch; ZFN, zygomatic branch of the facial nerve.
PPF is associated with a high degree of accuracy and feasibility. Further studies are required to confirm the efficacy and safety of maxillary nerve block for clinical applications.

**ACKNOWLEDGMENTS**

The authors thank Dr Chananya Hokierti for preparing the illustrations for this study.

**REFERENCES**