# Application of ultrasound guidance in the oral and maxillofacial nerve block

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**Introduction** Nerve block technology is widely used in clinical practice for pain management. Conventional nerve localization methods, which only rely on palpation to identify anatomical landmarks, require experienced surgeons. It, therefore, involves a certain risk. Visualization technologies like ultrasound guidance help surgeons locate anatomical structures in the surgical area and guide the puncture operation using different kinds of images, which can help avoid complications. There are several important and complex anatomical structures in the oral and maxillofacial regions. The current article reviews the application of ultrasound guidance in oral and maxillofacial nerve block. **Methods** We searched the literature on the use of ultrasound guidance for the main nerve block technique in the oral and maxillofacial regions in PubMed and MEDLINE and summarized the findings. **Results and Discussion** Review of the literature showed that ultrasound guidance improves the safety and effectiveness of several kinds of puncture procedures, including nerve block.

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## ABSTRACT

**Introduction** Nerve block technology is widely used in clinical practice for pain management. Conventional nerve localization methods, which only rely on palpation to identify anatomical landmarks, require experienced surgeons. It, therefore, involves a certain risk. Visualization technologies like ultrasound guidance help surgeons locate anatomical structures in the surgical area and guide the puncture operation using different kinds of images, which can help avoid complications. There are several important and complex anatomical structures in the oral and maxillofacial regions. The current article reviews the application of ultrasound guidance in oral and maxillofacial nerve block. **Methods** We searched the literature on the use of ultrasound guidance for the main nerve block technique in the oral and maxillofacial regions in PubMed and MEDLINE and summarized the findings. **Results and Discussion** Review of the literature showed that ultrasound guidance improves the safety and effectiveness of several kinds of puncture procedures, including nerve block.

## KEYWORDS

nerve block; ultrasound; mandibular nerve; maxillary nerve

## INTRODUCTION

Rationale of this study: The precise goal of nerve block can be described as “put the right dose of the right drug in the right place” (Denny & Harrop-Griffiths 2005). Conventional nerve localization methods are based on the identification of the anatomical landmarks via palpation on the body surface, which highly relies on the experience of the surgeons, and such localization methods are not suitable for patients with anatomical variations in nerves and blood vessels and with no perceived anatomical landmarks on the body surface. With the development of visualization technologies like ultrasound, CT, and MRI, surgeons can now observe the distribution and direction of nerves and blood vessels. Visualization technologies can greatly reduce the risk of adverse reactions and improve the efficiency of puncture procedures. Ultrasound guidance is widely used in nerve block procedures for upper and lower limbs and spine and celiac nerves. The current article presents a review of the progress in the application of ultrasound guidance in oral and maxillofacial nerve block. This article aims to increase the attention of doctors to visualization techniques when performing nerve block in maxillofacial region, thus develop more approaches to reduce injuries and improve efficiency of nerve blocks.

This article intended for oral and maxillofacial surgeons, dental emergency doctors, and neurosurgeons, providing them with more choices of visualization technology when they are performing nerve block or neuralgia treatment in daily clinical practice, and we hope they can develop more safe and effective approaches with the help of visualization technology.

## METHOD

We searched PubMed and MEDLINE for relevant publications. We used the “OR” and “AND” operations to search the literature on the different nerves and guidance methods. For instance, when searching publications on ultrasound guidance used in inferior nerve block, the search terms used were “ultrasound guidance”, OR “US”, or “ultrasound-guided” OR “US-guided”; AND “inferior alveolar nerve”, OR “IANB”. Since studies involved both the inferior alveolar and the mandibular nerve, “mandibular nerve” was searched at the same time. Since we did not find any review similar to the current one, we searched PubMed and MEDLINE for publications throughout the available literature. Most of the papers were published after 2010.

The inclusion criteria of the article include: The article must be written in English. The research subjects must be human or human corpse. The type of research papers selected were those pertaining to clinical trials, cohort studies, narrative studies, and case reports. And the exclusion criteria include: The research object is non-human, and the articles that do not use visualization technology but use other neural localization technology to guide nerve block procedure.

In total, 34 relevant publications were selected including 3 review articles.

The main anatomical structures and nerves involved in the current article are shown in the lateral view of the skull in Figure 1.

## RESULTS

1 Mandibular Nerve and Inferior Alveolar Nerve

The intraoral injection is the most commonly used method for inferior alveolar nerve block (IANB) in clinical practice. The puncture location is identified using several surface landmarks like the pterygomandibular ligament and the buccal fat pad. When practicing this approach, the needle is placed 1 cm above and parallel to the mandibular occlusal plane, and then, the surgeons administer anesthesia to the inner surface of the mandibular ramus, and the inferior alveolar nerve can be successfully blocked by the diffusion of the anesthetic drugs. (Aggarwal et al. 2010) This method is widely used clinically but studies have shown that its success rate is affected by the evaluation criteria, imparting a certain risk of failure to this surgery. (Abdallah et al. 2016; Potocnik & Bajrovic 1999) Studies have proposed different measures to improve the success rate, such as supplementary infiltration anesthesia, changing the anesthetic drug dose (Milani et al.), or using ultrasound-guidance methods. Ultrasound-guided IANB can be divided into intraoral and extraoral approaches.

1.1 Intraoral approach

Both the ultrasound probe and the injection needle are placed in the mouth in the intraoral approach. Hannan *et al.* (Hannan et al. 1999) compared ultrasound-guided IANB to the conventional techniques. When comparing the degree of anesthesia of the dental pulp in one side of the mandible, it was found that although the needle tip can be accurately placed around the nerve using ultrasound guidance, no significant difference was found in the success rate between the two techniques. The author also pointed out that the indicator of a successful block used in the study was “pulpal anesthesia”, which is different from the commonly used “lip and tongue numbness”. Also, in the same study, the inferior alveolar nerve could not be located using ultrasound, and the position of the inferior alveolar artery was used to locate the nerve. Chanpong *et al.* (Chanpong et al. 2013), using a new type of hockey stick-shaped ultrasound probe placed at the pterygomandibular ligament of the patients, could identify the inferior alveolar nerve. The average scanning time required to locate the left inferior alveolar nerve was only 19.6 s and that for the right inferior alveolar nerve was 30.5 s. The subjects stated that the probe did not cause any significant discomfort. In addition, the author successfully performed ultrasound-guided IANB using this method by injecting a dye in cadavers.

In summary, there are several criteria to evaluate the success of traditional IANB, and placing the needle around the nerve accurately is not the only factor that affects anesthesia. We can conclude that the introduction of ultrasound probably has little effect on the success rate of IANB in the intraoral approach. However, the application of ultrasound may increase the time taken for the surgery. Future studies addressing the safety of the method are needed.

1.2 Extraoral approach

In the extraoral approach of ultrasound-guided inferior alveolar nerve (or mandibular nerve) block, the ultrasound probe and the puncture point are located outside the mouth. The most common purpose behind the extraoral approach is to inject the anesthetic drugs into the pterygomandibular space. The relative positions of the ultrasound probe and the needle tip, and the correct recognition of the anatomical structures from the ultrasound images, are important for this procedure. Kumita *et al.* (Kumita et al. 2017) reported a type of extraoral approach to perform ultrasound-guided maxillary and inferior alveolar nerve block to induce analgesia after orthognathic surgery. In this method, the ultrasound probe was placed caudad to the zygomatic arch to observe the maxillary artery in the pterygomandibular space. And the selected injection site was just around the maxillary artery to help the anesthetic drug infiltrate the inferior alveolar nerve. This study also used the position of the maxillary artery to locate the nerve in the ultrasound images. Using the same method, Kojima *et al.* (Kojima et al. 2020) performed ultrasound-guided (extraoral approach)

IANB in patients having drug-related osteonecrosis and undergoing mandibular resection under general anesthesia. The after-surgery analgesic effect was better in the experimental group compared to the control group patients who didn't receive IANB, and the total amount of opioids used in the experimental group was significantly less. The above studies showed that ultrasound-guided injection of local anesthetics into the pterygomandibular space can achieve satisfactory results of inferior alveolar nerve (and mandibular nerve) block. Alternative to injecting the anesthetic drugs into the pterygomandibular space, Kampitak *et al.* (Kampitak et al. 2018b) performed a new ultrasound-guided selective mandibular nerve block in cadavers, called the lateral pterygoid plate approach, where the drugs were injected into the skull base. During the surgery, the corpse's mouth was wide open, the posterior and superior edges of the lateral pterygoid plate were identified using ultrasound, and the adjacent mandibular nerve and its branches were successfully stained by injecting a dye, indicating that a successful nerve block can be performed in the same way. Tsuchiya *et al.* (Tsuchiya et al. 2019) also used a similar approach, in which the lateral pterygoid plate was used as a landmark. In 10 cases of parotidectomy, low-molecular weight dextran and local anesthetics were used to block the mandibular nerve under ultrasound guidance, successfully reducing the involuntary movement of the muscles due to surgical stimulation during operation, thus reducing the need for general anesthesia.

In summary, there are relatively more studies on the extraoral approach of ultrasound-guided alveolar nerve (or mandibular nerve) block. In some types of the extraoral approach of the mandibular nerve or IANB, the patients do not need to open their mouths. Since there are patients who require mandibular nerve or IANB but cannot open the mouths due to trauma or pain, the extraoral approach of the alveolar nerve (or mandibular nerve) block is needed. However, in the extraoral approach, the needle goes deeper and the adjacent structures are more complex, and the ultrasound can better guide the needle. Jain *et al.* (Jain et al. 2016) performed closed-mouth high-position mandibular nerve block as known as Vazirani-Akinosi method(Prabhu Nakkeeran et al. 2019) and extraoral ultrasound-guided mandibular nerve block for patients with pain and trismus due to fracture or acute pain, before administering general anesthesia. To check for differences between these two block methods, the patients' visual analogue scale (VAS) scores of pain and the degree of relief from trismus, before and after the block, were compared. The results suggested that ultrasound can help accurately locate nerves and blood vessels, which are anterior to the condyle, and the drugs can be injected to the correct location. The ultrasound-guided group of patients required fewer anesthetic drugs, had fewer adverse reactions, and showed better anesthetic effects and higher success rates. The comparison across the different extraoral approaches of ultrasound-guided IANB is shown in table 1 and figure 2.

## 2 Maxillary Nerve

The extraoral approach is mainly used in ultrasound-guided maxillary nerve block. The ultrasound probes are usually placed below the zygomatic arch, and according to the location of the puncture point, the extraoral approach can be further divided into infrazygomatic and suprazygomatic approaches. (Anugerah et al. 2020)

2.1 Infrazygomatic Approach

Sola *et al.* (Sola et al. 2012) and Chiono *et al.* (Chiono et al. 2014) performed bilateral maxillary nerve block using ultrasound guidance in suprazygomatic approach for pain management in infants who underwent cleft palate repair surgery. In ultrasound images, anatomical structures in the pterygopalatine fossa and needle tip positions could be clearly distinguished in real-time imagines. The anesthetic drug was injected into the pterygopalatine fossa using ultrasound guidance, and the surgeons could control the spread of the anesthetic drug over time. The arterial pulsation also could be monitored to help avoid the risk of vascular puncture. Although the maxillary nerve could not be directly identified using the ultrasound images, the success rate and safety of the maxillary nerve block in this study were improved. After the surgery, all the patients with their maxillary nerve blocked showed better pain management, and fewer analgesic drugs were used. Another study (Bouzinac et al. 2014) performed maxillary nerve block during maxillary osteotomy in adult patients using the same method and indicated that this method was safer since it avoids the risk of penetrating the orbital contents through the infraorbital fissure. Echaniz *et al.* (Echaniz et al. 2019) used this method to conduct a study on cadavers to identify the anesthetic drug dose required in maxillary nerve block. The results showed that only 1 mL of liquid was needed to cover the nerve surface. In the study by Kumita *et al.* (Kumita et al. 2017), the maxillary nerve block was performed right after the mandibular nerve block, and the pterygoid fossa could be observed by adjusting the position of the probe. In this study, the insertion point was located at the angle formed by the superior edge of the zygomatic arch and the posterior orbital rim, and the injection site was at the lateral pterygoid plate. The authors pointed out that using ultrasound-guided maxillary and inferior alveolar nerve block at the same time significantly improved the effectiveness of perioperative analgesia during gnathoplasty.

2.1 Suprazygomatic Approach

The suprazygomatic approach is considered a safer approach, but normally it can only be performed using out-of-plane techniques, which are difficult. Moreover, due to the occlusion of the zygomatic arch, there is a period when the needle is seemingly invisible in the ultrasound images and the surgeons have to rely on their experience. (Anugerah et al. 2020)

Kampitak *et al.* (Kampitak et al. 2018a) introduced a kind of ultrasound-guided maxillary nerve block in the infrazygomatic approach in cadavers, using the posterior edge of the maxilla and the lateral pterygoid plate from the ultrasound images as landmarks. In this study, while the mouth of the corpse was wide open, the injection needle could approach the pterygopalatine fossa through the front edge of the lateral pterygoid plate. This method successfully simulated the block of the maxillary nerve, pterygopalatine ganglion, greater and lesser palatine nerves, and middle and posterior superior alveolar nerves by injecting a dye. The authors claimed that after administering general anesthesia, the degree of opening of the mouth could be increased. (Kampitak & Shibata 2019) In the infrazygomatic approach, there are two ways for the entry of the needle - the anterior and the posterior approaches. Alfaro-de *et al.* (Alfaro-de la Torre et al. 2019) compared these two approaches, and it was found that using the anterior approach, in which the needle goes front-to-back, can effectively avoid damage to the important structures like the facial nerve, parotid gland, and maxillary artery. However, it is relatively more difficult to perform. In addition to the two approaches described above, Takahashi *et al.* (Takahashi & Suzuki 2017; Takahashi & Suzuki 2018) reported a novel infrazygomatic approach, in which the needle passes from in front of the coracoid process, so we called it the coracoid approach. The main advantages of this novel method are that the needle path is far away from the main blood vessels, and the needle would not advance to the pterygopalatine fossa but instead to the infratemporal crest, which is safer. Besides, the mandibular nerve can be blocked at the same time, by tilting the ultrasound probe slightly posteriorly and advancing the needle vertically. Also, the discomfort in patients could be reduced since this method can be performed while the patient's mouth is closed. Chang *et al.* (Chang et al. 2017) and Ying *et al.* (Ying & Du 2017) introduced another method for the approach, where the needle goes between the coracoid process and the maxilla, and easily passes through the fissura pterygomaxillaris and reaches the pterygopalatine fossa, effectively avoiding the bone structures.

There are several studies on ultrasound-guided maxillary nerve block but there is still no consensus on which method is better. The comparison across the different approaches of ultrasound-guided maxillary nerve block is shown in table 2 and figure 3.

3 Trigeminal Ganglion

Ultrasound-guided trigeminal ganglion puncture is similar to maxillary nerve puncture. The nerve block of the trigeminal ganglion is used for the treatment of neuralgia of the trigeminal nerve and its branches. (Allam et al. 2018) Nader *et al.* (Nader et al. 2013a) injected anesthetic drugs and steroids under ultrasound guidance into the pterygopalatine fossa of 15 patients having trigeminal neuralgia and who had a failed surgery and drug treatment. The results showed that 80% of patients achieved complete analgesia in three branches of the nerve, and the authors believed that it was because the pterygopalatine fossa communicates with the foramen rotundum and the supraorbital fissure. The injection in the pterygopalatine fossa helps diffuse the anesthetic drugs to the middle cranial fossa through the foramen rotundum, thereby blocking the three branches of the trigeminal nerve. (Nader et al. 2013a; Nader et al. 2013b) Although the trigeminal ganglion is situated relatively deeper, by adjusting the angle of the ultrasound probe and the injection needle, surgeons can still advance the needle through the upper head of the lateral pterygoid muscle and the fissura pterygomaxillaris, finally to the foramen rotundum through the pterygopalatine fossa. (Chuang & Chen 2015) A subsequent study used this ultrasound-guided puncture method on a patient with trigeminal neuralgia, and the authors performed pulsed radiofrequency via pterygopalatine fossa, achieving satisfactory analgesic effects, and no recurrence was observed. (Nader et al. 2015) Kumar *et al.* (Kumar et al. 2018) used the same procedure on patients undergoing maxillofacial surgery for pain management, which reduced the amount of opioids used after surgery.

Ultrasound-guided trigeminal nerve block technology generally uses the infrazygomatic approach. Zou *et al.* (Zou et al. 2020) proposed a suprazygomatic approach, where both the ultrasound probe and the puncture point were located above the zygomatic arch. After identifying the landmark structures like the maxilla, the great wing of the sphenoid bone, and the pterygopalatine fossa using the ultrasound images, the anesthetic drugs were injected onto the surface of the maxilla. The comparison of the patients' skin sensation and the MRI images before and after the operation showed that this method helped spread the anesthetic drugs to the target nerves, and both the mandibular and maxillary nerves were blocked successfully. However, the blocking effect of the ophthalmic nerve was poor. This method does not require the patients to open their mouths and is, therefore, more comfortable. Also, in-plane technology can be easily achieved to reduce the difficulty of puncturing. However, the best way to perform ultrasound-guided trigeminal nerve block is debated. The comparison across the different approaches of ultrasound-guided maxillary nerve block is shown in table 3 and figure 4.

4 Other Nerves

In the oral and maxillofacial region, apart from the larger branches of the trigeminal nerve, like the maxillary and the mandibular nerves, some small branches can also be blocked using ultrasound guidance. (Allam et al. 2018) However, due to their superficial position, which means that these nerves can be blocked easily using landmark palpation, the application of ultrasound has not been widely promoted.

Michalek *et al.* (Michalek et al. 2013) used ultrasound to observe the position of the infraorbital foramen on a skull model. The authors predicted that it is feasible to block the infraorbital nerve under ultrasound guidance, and when the puncture point is located intraorally, the block can be performed using the in-plane technique because the path of the needle is longer. Other studies (Cok et al. 2017; Takechi et al. 2015) used ultrasound-guided infraorbital nerve block for patients with trigeminal neuralgia and isolated infraorbital neuralgia and showed that rapid and satisfactory analgesia was achieved after surgery; although, neuralgia recurred in both the studies. The results from another randomized double-blind clinical trial of ultrasound-guided infraorbital nerve block suggested that dexmedetomidine combined with bupivacaine gave a superior analgesic effect than dexamethasone combined with bupivacaine after cleft palate repair surgery. (El-Emam & El Motlb 2019)

Supraorbital neuralgia, too, is commonly observed. Cadaver studies (Spinner & Kirschner 2012) have demonstrated that ultrasound can be used to guide the injection to the supraorbital, infraorbital, and mental nerves. Luo *et al.* (Luo et al. 2018) and Ren *et al.* (Ren et al. 2020) studied the treatment of refractory supraorbital neuralgia with radiofrequency pulses and radiofrequency thermocoagulation, respectively, using ultrasound guidance. The results showed that both methods achieved satisfactory analgesic effects and no obvious adverse reactions were observed.

Hafeez *et al.* (Hafeez et al. 2014) performed greater palatine nerve block under ultrasound guidance with a hockey stick-shaped ultrasound probe in patients and cadavers. It was found that although ultrasound could locate the greater palatine artery and identify the greater palatine foramen and its direction effectively in the normal and edentulous maxilla, the block procedure could be challenging. The authors reported that a more suitable size of the ultrasound probe, a more suitable dose of local anesthetics, and ultrasound may be used in pre-procedural localization to achieve a successful greater palatine nerve block.

In the maxillofacial region, although some nerves are superficial, they are accompanied by blood vessels and the adjacent structures are complex. Ultrasound may play an important role in the visualization and guidance for the puncture operation. In the fields of nerve block and treatment of neuralgia, ultrasound has a great significance that cannot be underestimated.

## CONCLUSION

The biggest advantage of ultrasound is its convenience and real-time imaging capabilities, which may help the surgeons observe the blood vessels and nerves around the injection area and the diffusion of the anesthetics in real-time, thereby improving the success rate and safety of puncture procedures. While there are relatively fewer studies on the application of ultrasound guidance in oral and maxillofacial nerve block and no widely recognized standards, the comprehensive literature study suggested the superiority of using ultrasound to guide nerve block in the oral and maxillofacial region.

Also, ultrasound technology is constantly developing and there have been several suggestions to enhance the positioning abilities (such as needle visualization technology, endoscopic ultrasound, etc.). (O'Donnell & Loughnane 2019) More research on ultrasound guidance is needed in the future. With the advancement of imaging technologies, more problems may be solved with support from clinical trial studies and medical practitioners.

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## CONFLICTS OF INTEREST

The authors declare no financial or other relationships that might lead to a conflict of interest related to this study.

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## Figure captions

Figure1: Anatomy structure of part of the skull in lateral view. (A) Lateral view of part of the skull with mouth closed; (B) Lateral view of part of the skull after the zygomatic arch is removed with mouth closed, the pterygopalatine fossa is covered with coracoid process; (C) Lateral view of part of the skull the zygomatic arch and mandible are transparent; (D) Lateral view of part of the skull after the zygomatic arch is removed with mouth opened, the pterygopalatine fossa can be seen. (E) Enlarged image of pterygopalatine fossa.

SB: sphenoid bone; TB: temporal bone; CB: Cheekbone; ZA: zygomatic arch; TG: Trigeminal ganglion; FR: foramen rotundum; FO: foramen ovale; CP: coracoid process, LPP: lateral pterygoid plate; PF: pterygopalatine fossa; MdN: mandibular nerve; MxN: maxillary nerve; LN: lingual nerve; IAN: inferior alveolar nerve; PSAN: posterior superior alveolar nerve; PG: pterygopalatine ganglion.

Figure2: The needle position in different methods to perform ultrasound-guided mandibular nerve block in extraoral approach with mouth opened

1: The trajectory of the needle is perpendicular to the sagittal plane to reach the PMS, described by Kumita et al.

2: The needle reaches the posterior edge of the LPP through the infrazygomatic approach described by Kampitak et al.

Figure3: (A) The needle position in different methods to perform ultrasound-guided maxillary nerve block while the mouth is closed or slightly opened. The dotted line indicates that the needle is blocked by the zygomatic arch or coracoid process.1: Suprazygomatic approach described by Sola et al; 2: Coracoid approach of infrazygomatic approach described by Takahashi et al. (B) The needle position in different methods to perform ultrasound-guided maxillary nerve block while the mouth is opened. 3: Posterior approach of infrazygomatic approach described by Nader et al, the mouth is slightly opened; 4: Anterior approach of infrazygomatic approach described by Kampitak et al. in which the anterior edge of LPP is regarded as the landmark of puncturing.

Figure4: The needle position in different methods to perform ultrasound-guided Trigeminal Ganglion block.

It is described in studies that the injection in pterygopalatine fossa can make the anesthetic drugs diffuse through the foramen rotundum, to the middle cranial fossa, thereby block three branches of trigeminal nerve.

1: Infrazygomatic approach described by Nader et al.

2: Suprazygomatic approach described by Zou et al.

# Figure 1

Figure1: Anatomy structure of part of the skull in lateral view

(A) Lateral view of part of the skull with mouth closed; (B) Lateral view of part of the skull after the zygomatic arch is removed with mouth closed, the pterygopalatine fossa is covered with coracoid process; (C) Lateral view of part of the skull the zygomatic arch and mandible are transparent; (D) Lateral view of part of the skull after the zygomatic arch is removed with mouth opened, the pterygopalatine fossa can be seen. (E) Enlarged image of pterygopalatine fossa.

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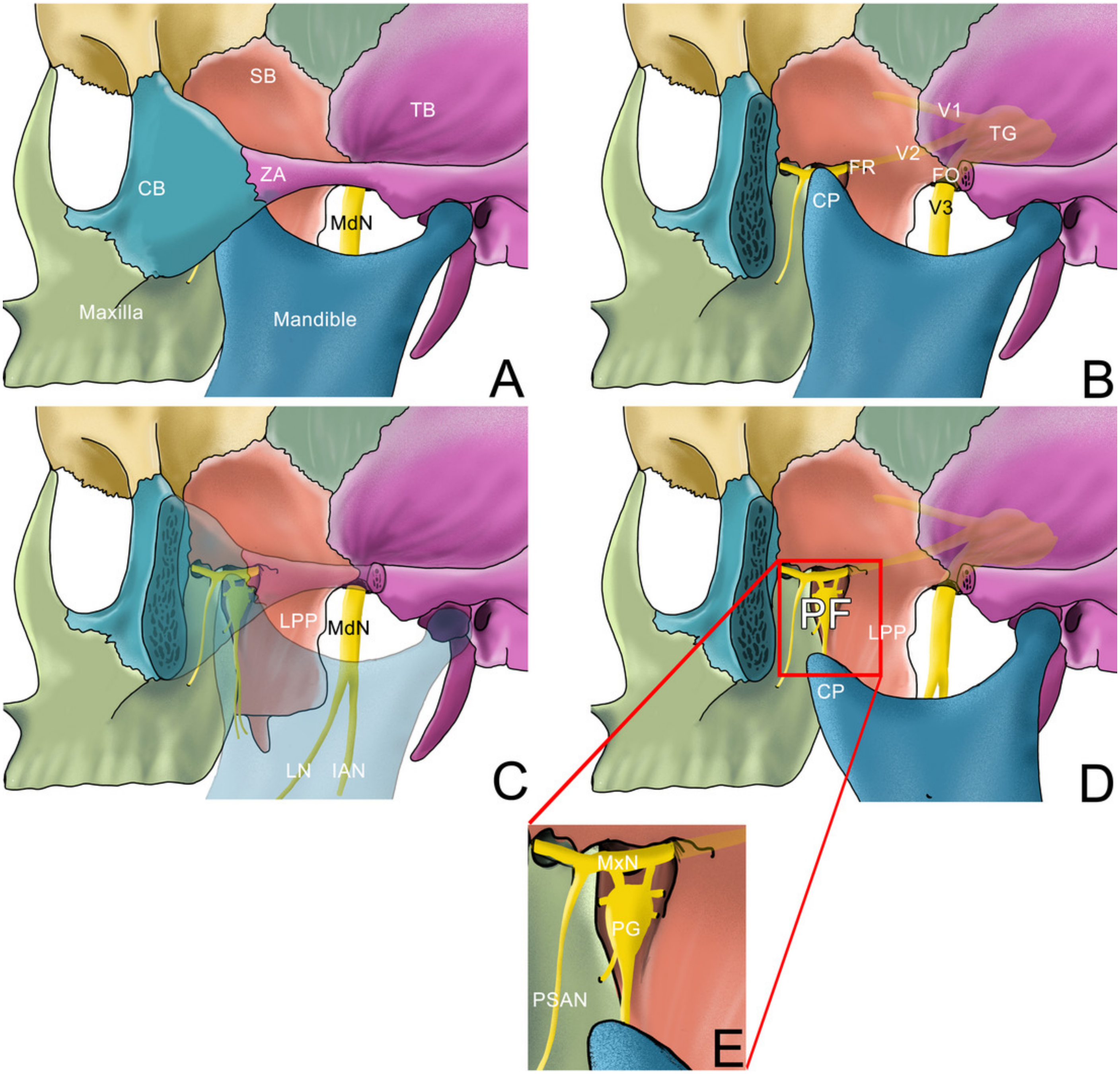
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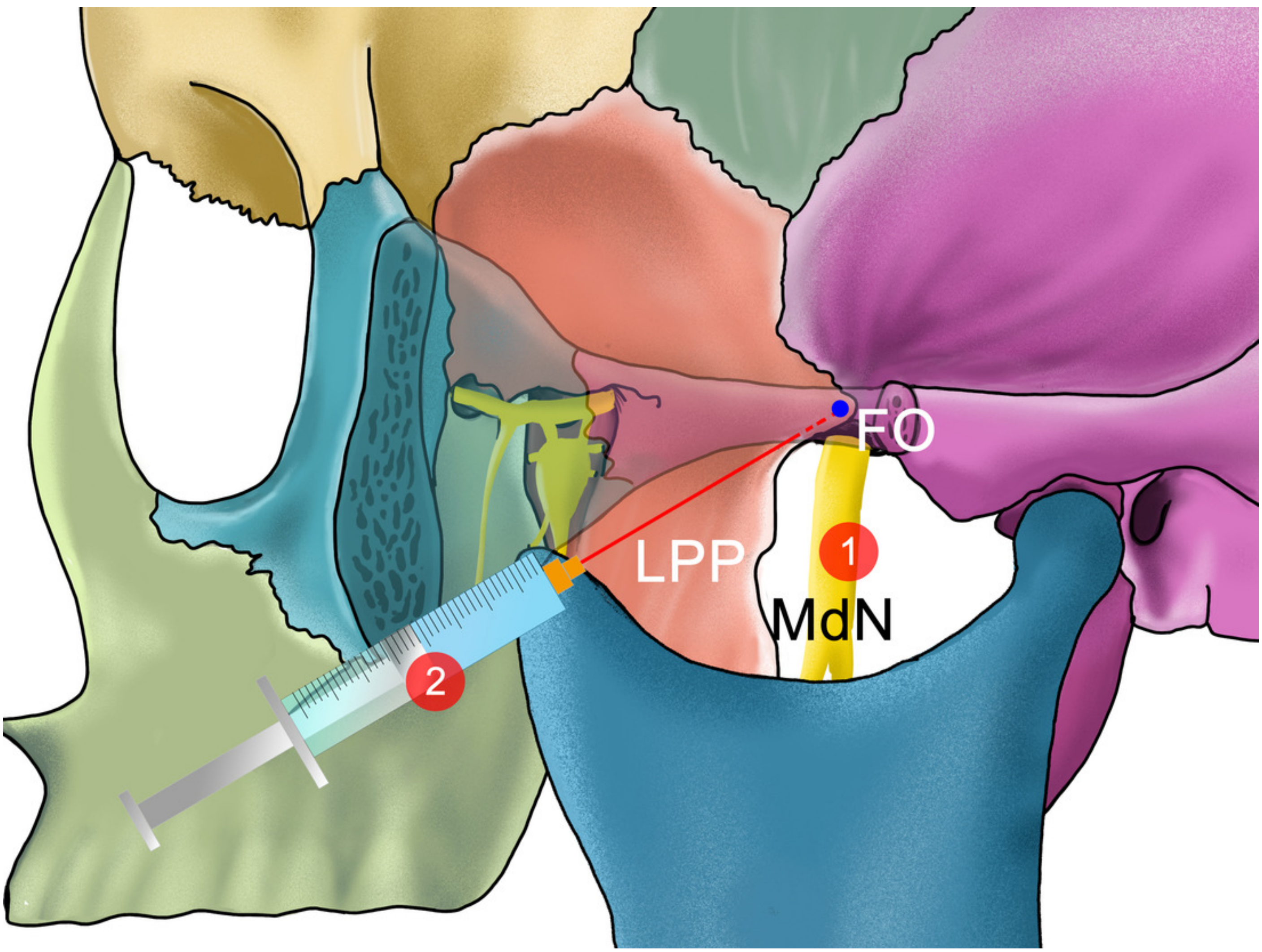
# Figure 2

Figure2: The needle position in different methods to perform ultrasound-guided mandibular nerve block in extraoral approach with mouth opened

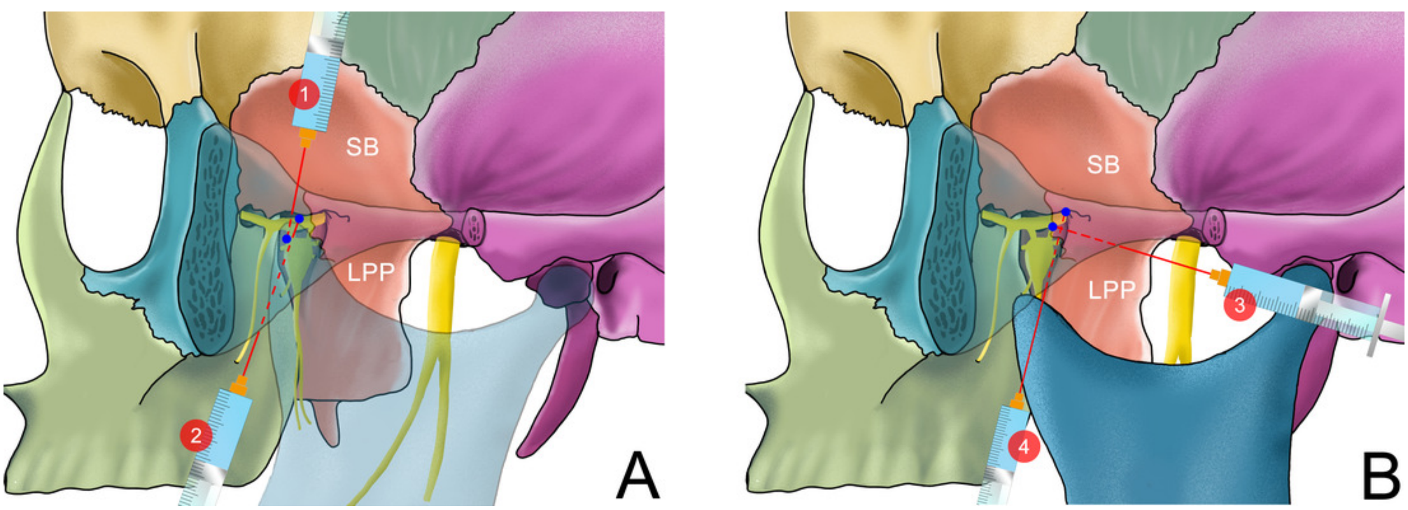
1: The trajectory of the needle is perpendicular to the sagittal plane to reach the PMS, described by Kumita et al. 2: The needle reaches the posterior edge of the LPP through the infrazygomatic approach described by Kampitak et al.



# Figure 3

Figure3: The needle position in different methods to perform ultrasound-guided maxillary nerve block

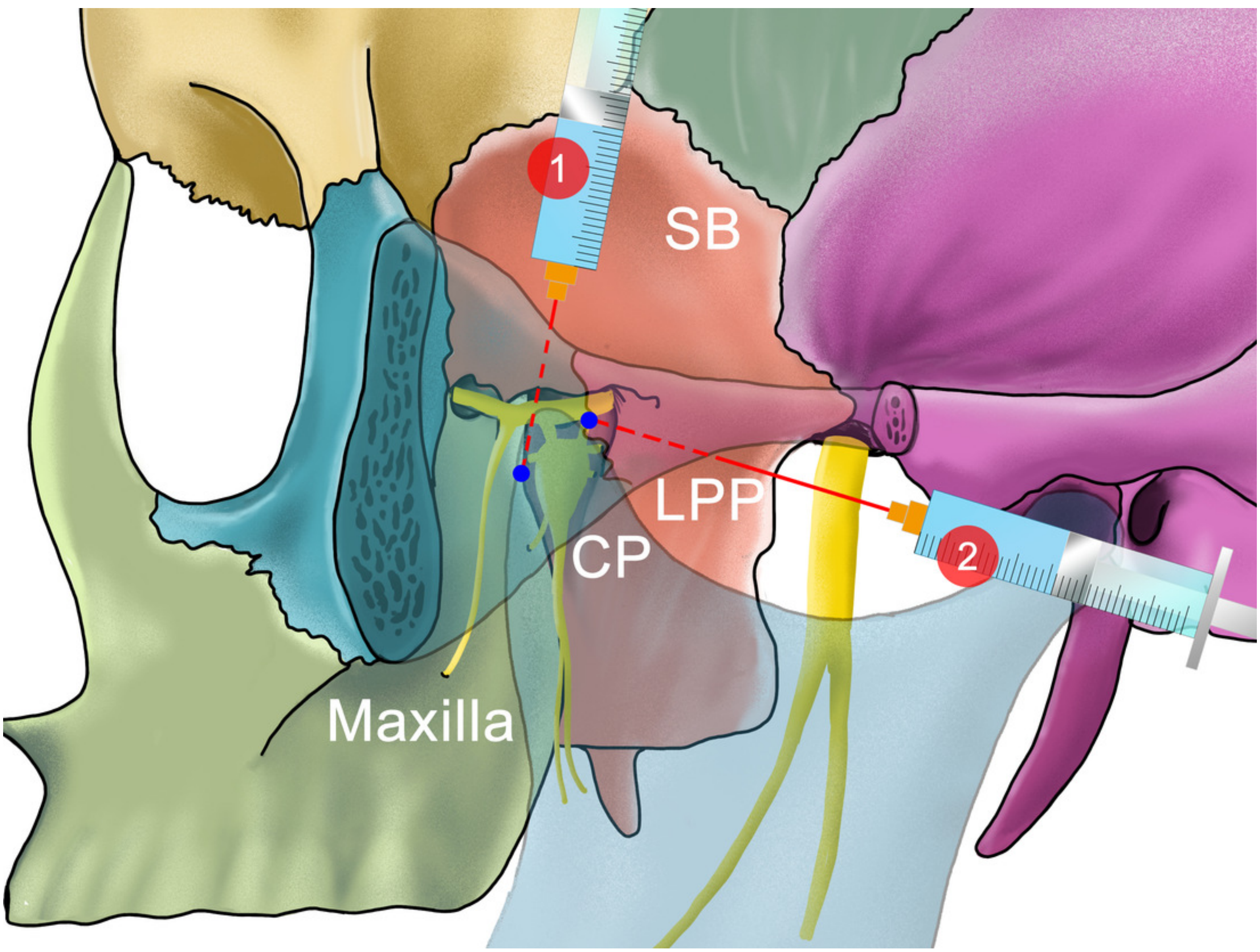
(A) The needle position in different methods to perform ultrasound-guided maxillary nerve block while the mouth is closed or slightly opened. The dotted line indicates that the needle is blocked by the zygomatic arch or coracoid process.1: Suprazygomatic approach described by Sola et al; 2: Coracoid approach of infrazygomatic approach described by Takahashi et al. (B) The needle position in different methods to perform ultrasound-guided maxillary nerve block while the mouth is opened. 3: Posterior approach of infrazygomatic approach described by Nader et al, the mouth is slightly opened; 4: Anterior approach of infrazygomatic approach described by Kampitak et al. in which the anterior edge of LPP is regarded as the landmark of puncturing.



# Figure 4

Figure4: The needle position in different methods to perform ultrasound-guided Trigeminal Ganglion block.

It is described in studies that the injection in pterygopalatine fossa can make the anesthetic drugs diffuse through the foramen rotundum, to the middle cranial fossa, thereby block three branches of trigeminal nerve. 1: Infrazygomatic approach described by Nader et al. 2: Suprazygomatic approach described by Zou et al.



## Table 1(on next page)

Table 1: Comparison of Different Approaches of Ultrasound Guided Mandibular Nerve and Inferior Alveolar Nerve Block

**ZA: zygomatic arch; LPP: lateral pterygoid plate; PS: pterygomandibular space**

| Target nerve | Approach | Authors | Subjects | Position of ultrasound probe | Puncture point | Inject point | Ultrasound-guided puncture method | Main advantages | Possible disadvantages |
|---|---|---|---|---|---|---|---|---|---|
| Mandibular nerve or inferior alveolar nerve | Intraoral | Hannna, 1999 | Patients | The oral mucosa on medial aspect of the mandibular ramus | Intraoral | IAN at PS | In palne | Locate the nerve accurately, Avoid inadvertent intraneural injection and entry into surrounding structures | The success rate was not significantly improved; Possible increase in operating time |
| | | Chanpong, 2013 | Patients and cadavers | Pterygomandibular raphe | Intraoral | IAN at PS | - | | |
| | Extraoral | Kumita, 2017; Kojima 2020 | Patients | Caudad to ZA. | Below the ZA | Maxillary artery | Out of plane | | Large degree of mouth opening |
| | | Kampitak, 2018 | Cadavers | Transversely below the ZA. | Below the ZA | The Posterior border of the LPP | In plane | | Large degree of mouth opening |
| | | Tsuchiya, 2019 | Patients | Below and parallel to the ZA | - | Dorsal edge of LPP | - | | |
| | | Jain, 2016 | Patients | Superior to the mandible (linear ultrasound probe); below the zygoma and anterior to the mandibular | Superior (linear ultrasound probe) or posterior (cardiac probe) to | Mandibular nerve | Out of plane (linear ultrasound probe) | No need to open mouth Reduce the dosage of local anesthetics | |

| | | | | | |
|---|---|---|---|---|---|
| | condyle (cardiac probe) | the probe | | In-line (cardiac probe) | and avoid vascular puncture |

**Table 1: Comparison of Different Approaches of Ultrasound Guided Mandibular Nerve and Inferior Alveolar Nerve Block**

**ZA: zygomatic arch; LPP: lateral pterygoid plate; PS: pterygomandibular space**

## Table 2 (on next page)

Table 2: Comparison of Different Approaches of Ultrasound Guided Maxillary Nerve Block

ZA: zygomatic arch; LPP: lateral pterygoid plate; PF: pterygopalatine fossa

| Target nerve | Approach | Authors | Subjects | Position of ultrasound probe | Puncture point and needle position | Inject point | Ultrasound -guided puncture method | Main advantages | Possible disadvantages |
|---|---|---|---|---|---|---|---|---|---|
| Maxillary nerve | Suprazygomatic approach | Sola, 2012<br>Chiono, 2014<br>Bouzinac, 2014 | Patients | Infrazygomatic area, over the maxilla, with an inclination of 45° in both the frontal and horizontal planes | The angle formed by the superior edge of the ZA and the posterior edge of orbital rim. | The greater wing of the sphenoid at PF | Out of plane | Reduce postoperative analgesic dose<br>Help locate the needle and prevent the puncture of orbital contents | |
| | | Echaniz, 2019 | Cadavers | | | | | | |
| | Anterior approach (infrazygomatic) | Kampitak, 2018 | Cadavers | Transversely below the ZA and was tilted from the caudal to the cranial direction | - | At the top of LPP at PF | In plane | By inserting the needle from front to back, avoiding puncture the parotid gland, the facial nerve and maxillary artery. | Large degree of mouth opening;<br>A very sharp needl entry angle is needed<br>Sonographic visualization can be difficult |
| | Posterior approach (infrazygomatic) | Alfaro-de, 2019 | Cadavers | - | - | - | - | Easier to perform | It can possibly lead t injury to some vital organs, and needle pathway is longer |
| | Coracoid approach(infrazygomatic) | Takahashi, 2017,2018 | Patients | Below the zygomatic process of the maxilla and tilted slightly in the superior direction. | Between the maxilla and coronoid process | Infratemporal crest | Out of plane | The needle does not enter into PF;<br>Patients don't have to open their mouth;<br>Mandibular nerve can be blocked at the same | - |

time

**Table 2: Comparison of Different Approaches of Ultrasound Guided Maxillary Nerve Block**

**ZA: zygomatic arch; LPP: lateral pterygoid plate; PF: pterygopalatine fossa**

## Table 3(on next page)

Table 3: Comparison of Different Approaches of Ultrasound Guided Trigeminal Ganglion Block

ZA: zygomatic arch; LPP: lateral pterygoid plate; PF: pterygopalatine fossa

| Target nerve | Approach | Authors | Subjects | Position of ultrasound probe | Puncture point and needle position | Inject point | Ultrasound -guided puncture method | Main advantages | Possible disadvantages |
|---|---|---|---|---|---|---|---|---|---|
| Trigeminal Ganglion | infrazygo matic approach | Nader 2013, 2015; Chuang 2015 | Patients | Below the ZA, longitudinally on the side of face. | Parallel to the probe | Below the lateral pterygoid muscle, anterior to the LPP at PF, PF, | In plane<br>Out of plane | The subject's mouth was just slightly opened | Mouth was kept open |
| | | Kumar, 2018 | Patients | Below the ZA, longitudinally on the side of face and superior to mandibular notch, anterior to the mandibular condyle | | | | | |
| | Suprazygo matic approach | Zou, 2020 | Patients | Longitudinally on the side of the face just on the ZA and shifted cranially temporal fossa appeared and the ZA vanished in the ultrasound images. | Posterior side of the probe | Maxilla surface | In plane | The needle does not enter into PF; Patients don't have to open their mouth. | Ophthalmic nerve cannot be blocked |

**Table 3: Comparison of Different Approaches of Ultrasound Guided Trigeminal Ganglion Block**

**ZA: zygomatic arch; LPP: lateral pterygoid plate; PF: pterygopalatine fossa**