Application of ultrasound guidance in the oral and maxillofacial nerve block

Zhiwei Cao[1], Kun Zhang[1], Liru Hu[1], Jian Pan[1]

Affiliations:

1 State Key Laboratory of Oral Diseases & National Clinical Research Center for Oral Diseases & West China Hospital of Stomatology, Sichuan University, Dept. of Oral Surgery, Chengdu, Sichuan, China.

Address correspondence to:

Jian Pan, D.D.S, M.D, Dept. of Oral Surgery, West China Hospital of Stomatology, Sichuan University, No.14, Section 3rd, Renmin Nan Road. 610041. Chengdu, Sichuan, China (email: jianpancn@163.com)

Deleted: Aaffiliations

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 and can be risky Visualization technologies like ultrasound guidance can help prevent complications by helping surgeons to locate anatomical structures in the surgical area and by guiding the operation using different kinds of images. 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 blocks. **Methods** We searched the literature on the use of ultrasound guidance for the main nerve block techniques in the oral and maxillofacial regions using both PubMed and MEDLINE and summarized the findings. **Results and Discussion** A review of the literature showed that ultrasound guidance improves the safety and effectiveness of several kinds of puncture procedures, including nerve blocks. There are two approaches to blocking the mandibular nerve: intraoral and extraoral. This review found that the role of ultrasound guidance is more important in the extraoral approach. There are also two approaches to the blocking of the maxillary nerve and the trigeminal ganglion under ultrasound guidance: the supra-zygomatic approach and the infra-zygomatic approach. The infra-zygomatic approach can be further divided into the anterior approach and the posterior approach. It is generally believed that the anterior approach is safer and more effective. This review found that the effectiveness and safety of most oral and maxillofacial nerve block operations can be improved through the use of ultrasound

Deleted: . It, therefore, involves a certain risk

Deleted: e

Deleted: puncture

Deleted: , which can help avoid complications.

Deleted:

Commented [AH1]: Try not to use “we” . Please rephrase

Deleted: in

Formatted: Font colour: Red

Deleted: R

Deleted: .

Deleted: The

Deleted: of

Deleted: under ultrasound guidance

Deleted: can be divided into

Deleted:

Deleted: approaches

Deleted: , and the

Deleted: under ultrasound guidance

Deleted: can be divided into

Deleted: e

Formatted: Font colour: Red

Formatted: Font colour: Red

Formatted: Font colour: Red

Deleted: will be

Deleted: Under the guidance of ultrasound, t

Deleted: e

guidance

KEYWORDS

nerve block; ultrasound; mandibular nerve; maxillary nerve

INTRODUCTION

The precise goal of a 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 anatomical landmarks via palpation on the surface of the body. This technique relies heavily on the experience of the surgeons, and such localization methods are not suitable for patients with anatomical variations in nerves and blood vessels or patients with no perceived anatomical landmarks on the surface of the body. 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 (reference). Ultrasound also has a wide range of applications in the oral and maxillofacial region, including ultrasonic scaling, ultrasound diagnosis, ultrasound-guided puncture procedures, and ultrasound thermo-chemotherapy (Figure 1), but there are relatively few studies on ultrasound-guided oral and maxillofacial nerve blocks (reference). The current article presents a review of the progress in the application of ultrasound guidance in oral and maxillofacial nerve

Deleted: ¶

Deleted: Rationale of this study:

Deleted: f the

Deleted: surface

Deleted: ,

Deleted: which

Deleted: highly

Deleted: and

Deleted: body surface

Formatted: Font colour: Red

Formatted: Font colour: Red

Deleted: .

Formatted: Font colour: Red

Deleted: In fact,

Deleted: uUltrasound guidance is widely used in nerve block procedures for upper and lower limbs and spine and celiac nerves. …

blocks. This article aims to increase physician awareness of visualization techniques when performing nerve blocks in the maxillofacial region in order to reduce injuries and improve the efficiency of nerve blocks. Please include the prevalence of injuries with the current techniques.

This article is intended for oral and maxillofacial surgeons, dental emergency doctors, and neurosurgeons, providing them with more visualization technology choices when performing nerve blocks or neuralgia treatment in daily clinical practice. It is our hope that these providers can develop more safe and effective treatment approaches with the help of visualization technology.

METHODS

1 Literature Search Strategy

The present study was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al. 2009). We comprehensively searched the PubMed and MEDLINE databases, using the following keywords or Medical Subject Heading (MeSH) terms: 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 blocks, 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,

Deleted: the attention of doctors
Deleted: to
Deleted: , thus develop more approaches
Formatted: Highlight
Formatted: Font colour: Red
Deleted: choices of
Deleted: they are
Deleted: , and we hope they
Formatted: Font colour: Red
Commented [AH2]: Same comment as above
Deleted: .
Formatted: Font colour: Red
Formatted: Font colour: Red
Formatted: Font colour: Red
Commented [AH3]: Same comment as above
Deleted: .
Formatted: Font colour: Red
Deleted: ,
Deleted: ,
Deleted: ;
Deleted: ,
Deleted: .
Commented [AH4]: Same comment as above
Formatted: Font colour: Red

we did not impose restrictions on the year of publication.

2 Study Selection Criteria

The studies were independently reviewed by two authors and any discrepancies were resolved by discussion and consensus. Studies were included based on the following criteria: (1) written in the English language; (2) had human subjects (including autopsy studies); and (3) were a clinical trial, cohort study, narrative study, or case report. We excluded studies that were: (1) not written in English; (2) did not have human subjects; and (3) did not use visualization technology but used other neural localization technology to guide nerve block procedures. In total, 34 relevant publications were included in this review including 3 existing review articles (Figure 2).

3 Assessment of levels of evidence

The evidence levels of the articles were assessed by the first author using the 2014 version of the Joanna Briggs Institute (JBI) Levels of Evidence. Evidence was ranked into one of five levels: level 1 = very high, level 2 = high, level 3 = moderate, level 4 = low and level 5 = very low.

RESULTS

We grouped the 34 included studies according to the nerves targeted in the study. We found that the most common target nerves for nerve block procedures in the oral and maxillofacial region are the inferior alveolar nerve, the mandibular nerve, the maxillary

Commented [AH5]: Same comment as above

Formatted: Font colour: Red

Deleted: o

Deleted: The article must be…written in the English language;….(2) The research subjects must be human or human corpse…ad human subjects (including autopsy studies). … and (3) were a The type of research papers selected were those pertaining to …linical trials… cohort studyies… narrative studyies… orand…case reports ... [1]

Commented [AH6]: Same comment as above

Formatted: Font colour: Red

Deleted: with the following criteria… (1) non-English language…ot written in English; (2) did not have human subjectsThe research object is non-human…….and (3) Articles that do …id not use visualization technology but used other neural localization technology to guide nerve block procedures. In total, 34 relevant publications were elected… ... [2]

Deleted: our

Formatted: Font colour: Red

Deleted:

Deleted: .

Formatted: Font colour: Red

Deleted: 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 ... [3]

Deleted: .

Formatted: Font colour: Red

Commented [AH7]: Same comment as above

Commented [AH8]: Same comment as above

Deleted: For the selected literature (including basic research ... [4]

Formatted: Font colour: Red

Deleted: target

Formatted: Font colour: Red

Deleted: of

Deleted: :

nerve and the trigeminal ganglion. We found that a nerve block of the mandibular nerve and the inferior alveolar nerve are frequently done at the same time, so we merged these two groups in this article. For blocks of the same nerve, we grouped different approaches. In addition to the target nerves mentioned above, there were also studies describing ultrasound-guided nerve blocks of other nerves including the infraorbital nerve and the supraorbital nerve. These were included in the "other nerves" section in this article.

The main anatomical structures and nerves involved in the current article are shown in the lateral view of the skull in Figure 3.

1 The Mandibular Nerve and The Inferior Alveolar Nerve

Intraoral injection is the most commonly used method for inferior alveolar nerve blocks (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. Surgeons administer anesthesia to the inner surface of the mandibular ramus, and then the inferior alveolar nerve can be successfully blocked through the diffusion of anesthetic drugs (Aggarwal et al. 2010). This method is widely used clinically, but studies have shown that its success rate is affected by the specific occasion, which means different types of dental treatment have different requirements for IANB (Potocnik & Bajrovic, 1999; Abdallah et al. 2016). Studies have proposed different measures to improve the success rate, such as supplementary infiltration anesthesia,

Commented [AH9]: Same comment as above

Deleted: Through the description of the literatures, the blocks…

Formatted: Font colour: Red

Deleted: of

Commented [AH10]: Same comment as above

Deleted: often achieved

Deleted: thus

Formatted: Font colour: Red

Commented [AH11]: Same comment as above

Deleted: the

Deleted: for

Formatted: Font colour: Red

Deleted: are also literatures

Deleted: ed

Deleted: ,

Deleted: , etc. all of which are

Deleted: The i

Deleted: , and then, the

Deleted: s

Deleted: by

Deleted: the

Deleted: .

Deleted: evaluation criteria

Deleted: imparting a certain risk of failure to this surgery.

Deleted: ; Potocnik & Bajrovic 1999

changing the anesthetic drug dose (Milani et al. year?), or using ultrasound-guidance methods. Ultrasound-guided IANB can be divided into intraoral and extraoral approaches.

1.1 Intraoral approach

In the intraoral approach, both the ultrasound probe and the injection needle are placed in the mouth. Hannan *et al.* (Hannan et al. 1999) compared ultrasound guided IANB to conventional techniques. When comparing the degree of anesthesia of the dental pulp in one side of the mandible, ~~they~~ 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, so the position of the inferior alveolar artery was used to locate the nerve. Chanpong *et al.* (Chanpong et al. 2013) were able to identify the inferior alveolar nerve using a new type of hockey stick-shaped ultrasound probe placed at the patient's pterygomandibular ligament. The average scanning time required to locate the left inferior alveolar nerve was only 19.6 seconds and the scanning time required to locate the right inferior alveolar nerve was 30.5 seconds. The subjects stated that the probe did not cause any significant discomfort. In addition, the author successfully performed ultrasound guided IANB on cadavers using this method by injecting a dye in order to simulate the diffusion of anesthesia

Commented [AH12]: Year?

Deleted: B

Commented [AH13]: Please follow the citation format of the journal

Deleted: in the intraoral approach

Deleted: ultrasound-guided

Deleted: the

Commented [AH14]: Same comment as above

Formatted: Strikethrough

Deleted: it was

Formatted: Strikethrough

Deleted: ,

Deleted: .

Deleted: and

Formatted: Highlight

Formatted: Highlight

Deleted: ,

Deleted: of the patients, could identify the inferior alveolar nerve…

Deleted: that for

Deleted: ultrasound-guided

Deleted: see

drugs around the nerve when performing this procedure.

In summary, there are several criteria to evaluate the success of traditional IANB, and accurately placing the needle around the nerve is not the only factor that affects anesthesia. Future studies addressing the safety of this method are needed as there are only a few studies (including basic research and clinical research) on the intraoral approach to ultrasound-guided inferior alveolar nerve blocks. It is too early to conclude that the introduction of ultrasound has any effect on the success rate of IANB in the intraoral approach. More studies are needed to explore whether ultrasound can guide this operation.

1.2 Extraoral approach

In the extraoral approach of ultrasound-guided inferior alveolar nerve (or mandibular nerve) blocks, the ultrasound probe and the puncture point are located outside of 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 performing an 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. The selected injection site was just around the maxillary artery to help the anesthetic drug

Deleted: the results of the

Deleted: in cadavers

Deleted: accurately

Formatted: Font colour: Red

Deleted: We can conclude that the introduction of ultrasound probably has little effect on the success rate of IANB in the intraoral approach

Deleted: . However, the

Deleted: taken

Deleted: and the application of ultrasound may actually increase the time needed

Deleted: for the surgery. F

Deleted: e

Deleted: . However, it is worth mentioning that there are

Deleted: probably

Deleted: little

Deleted: T

Deleted: , more literature support is needed.

Deleted: ,

Formatted: Highlight

Formatted: Highlight

Deleted: And t

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 of patients who did not receive IANB, and the total amount of opioids used in the experimental group was significantly less than the amount used by patients in the control group. The above studies showed that ultrasound-guided injection of local anesthetics into the pterygomandibular space can achieve satisfactory results in inferior alveolar nerve (and mandibular nerve) blocks. As an 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 base of the skull. During the surgery, the cadaver'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 ten 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

Formatted: Highlight
Formatted: Highlight
Deleted: n't
Deleted: of
Deleted: A
Formatted: Highlight
Formatted: Highlight
Deleted: ,
Deleted: base
Deleted: corpse's
Formatted: Highlight
Formatted: Highlight
Deleted: 10

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) blocks compared to number of studies on the intraoral approach. In some variations of the extraoral approach of the mandibular nerve or IANB, patients do not need to open their mouths. Since there are some patients who require a mandibular nerve or IANB that cannot open their mouths due to trauma or pain, the extraoral approach of the alveolar nerve (or mandibular nerve) block is sometimes necessary. However, in the extraoral approach, because the needle goes deeper and the adjacent structures are more complex, the ultrasound can better guide the needle. Jain *et al.* (Jain et al. 2016) performed closed-mouth high-position mandibular nerve blocks, known as the Vazirani-Akinosi method (Prabhu Nakkeeran et al. 2019) and extraoral ultrasound-guided mandibular nerve blocks in 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 visual analogue scale (VAS) pain scores and the degree of relief from trismus before and after the block for each patient was compared. The results suggest that ultrasound can help accurately locate nerves and blood vessels anterior to the condyle and assist with injecting anesthetics into 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 of block. The comparison of the different extraoral approaches of ultrasound guided IANB is shown in Table 1 and Figure 4.

Deleted: types
Deleted: the
Deleted: but
Deleted: eded
Deleted: and
Deleted:
Formatted: Highlight
Formatted: Highlight
Deleted: as
Deleted: (
Deleted: ,
Deleted: for
Deleted: patients’
Deleted: scores of
Deleted: ,
Deleted: ,
Deleted: ere
Deleted: ed
Deleted: , which are
Deleted: ,
Deleted: the drugs can be
Deleted: ed
Deleted: across
Deleted: ultrasound-guided
Deleted: t
Deleted: figure 2

2 Maxillary Nerve

The extraoral approach is the most common approach used in ultrasound-guided maxillary nerve blocks. In this procedure, the ultrasound probe is usually placed below the zygomatic arch. The extraoral approach can be further divided into the infra-zygomatic and supra-zygomatic approaches depending on the location of the puncture point (Anugerah et al. 2020).

2.1 Supra-zygomatic approach

Sola *et al.* (Sola et al. 2012) and Chiono *et al.* (Chiono et al. 2014) performed bilateral maxillary nerve blocks using ultrasound guidance and the supra-zygomatic 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 images. The anesthetic drug was injected into the pterygopalatine fossa using ultrasound guidance, and the surgeons could control the spread of the anesthetic over time. The arterial pulsation could also be monitored to help avoid the risk of vascular puncture. Although the maxillary nerve could not be directly identified using ultrasound images, the success rate and safety of the maxillary nerve block in this study were both improved. After the surgery, all patients with a maxillary nerve block had better pain management and used fewer analgesic drugs. Another study (Bouzinac et al. 2014) performed maxillary nerve blocks during maxillary osteotomy operations in adult patients using supra-zygomatic

Deleted: mainly used
Deleted: T
Deleted: s
Deleted: are
Deleted: ,
Deleted: and according to the location of the puncture point, t…
Deleted: .
Deleted: Infrazygomatic Approach
Formatted: Highlight
Formatted: Highlight
Formatted: Highlight
Formatted: Highlight
Deleted: in
Deleted: in
Deleted: drug
Deleted: also
Deleted: the
Deleted: the
Deleted: their
Deleted: ed
Deleted: showed
Deleted: ,
Deleted: were used
Deleted: y
Deleted: y

approach and determined that this method was safer as 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 for a 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), a maxillary nerve block was performed right after a 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 blocks at the same time significantly improved the effectiveness of perioperative analgesia during gnathoplasty.

2.1 Infra-zygomatic Approach

The supra-zygomatic approach mention above is considered a safer approach by many scholars, 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 and the surgeons have to rely on their experience (Anugerah et al. 2020). So, there are infra-zygomatic approach which can solve these problems.

Kampitak *et al.* (Kampitak et al. 2018a) introduced a kind of ultrasound-guided maxillary nerve block using the infra-zygomatic approach in cadavers, using ultrasound

Deleted: the same method
Deleted: indicated
Deleted: since it
Formatted: Highlight
Formatted: Highlight
Deleted: in
Formatted: Highlight
Deleted: the
Formatted: Highlight
Deleted: the
Deleted: Suprazygomatic
Deleted: T
Deleted: images
Deleted: .
Formatted: Highlight
Formatted: Highlight
Deleted: in

images of the posterior edge of the maxilla and the lateral pterygoid plate as landmarks. In this study, while the mouth of the cadaver 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 in place of an analgesic to see how the analgesic would spread in the nerves. The authors claimed that after administering general anesthesia, the degree of opening of the mouth could be increased (Kampitak & Shibata 2019). In the infra-zygomatic approach, there are two ways for the needle to enter: the anterior and posterior approaches. Alfaro-de *et al.* (Alfaro-de la Torre et al. 2019) compared these two approaches and found that the anterior approach, in which the needle goes front-to-back, can effectively avoid damage to important structures like the facial nerve, parotid gland, and maxillary artery. However, the anterior approach is more difficult to perform. In addition to the two approaches described above, Takahashi *et al.* (Takahashi & Suzuki 2017; Takahashi & Suzuki 2018) reported a novel infra-zygomatic approach, in which the needle passes from in front of the coronoid process. In this paper, we refer to this method as "the coracoid approach". The main advantages of this novel method are that the path of the needle 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. The mandibular nerve can also be blocked at the same time by tilting the ultrasound probe slightly posteriorly and advancing the needle vertically. Patient discomfort could also be reduced since this method can be performed while the patient's

Deleted: from the ultrasound images
Deleted: orpse
Deleted: by injecting a dye
Deleted: .
Deleted: entry of the needle
Deleted: - t
Deleted:
Deleted: the
Formatted: Highlight
Formatted: Highlight
Deleted: , and it was
Deleted: using
Deleted: the
Deleted: it
Deleted: relatively
Formatted: Highlight
Formatted: Highlight
Commented [AH15]: Same comment as above
Deleted: coracoid
Deleted: ,
Deleted: so we called
Commented [AH16]: ?
Deleted: it
Deleted: .
Deleted: the needle
Deleted: Besides, t
Deleted: ,
Deleted: Also, the discomfort in p
Deleted: s
Deleted: be

mouth is closed. Chang *et al.* (Chang et al. 2017) and Ying *et al.* (Ying & Du 2017) introduced another version of the infra-zygomatic approach where the needle goes between the coracoid process and the maxilla and easily passes through the fissura pterygomaxillaris to reach the pterygopalatine fossa, effectively avoiding the bone structures.

There are several studies on ultrasound-guided maxillary nerve blocks, but there is still no consensus on which method is better. The comparison of the different approaches to ultrasound-guided maxillary nerve blocking is shown in Table 2 and Figure 5.

3 Trigeminal Ganglion

An ultrasound-guided trigeminal ganglion puncture is similar to a maxillary nerve puncture. A nerve block of the trigeminal ganglion is used as a treatment for 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 fifteen patients who had trigeminal neuralgia and who had failed both surgery and drug treatments. The results showed that 80% of patients achieved complete analgesia in three branches of the nerve. The authors hypothesize that the high success of this procedure is 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

Formatted: Highlight
Formatted: Highlight
Formatted: Highlight
Formatted: Highlight
Deleted: method
Deleted: for
Deleted: ,
Deleted: ,
Deleted: and
Deleted: es
Deleted: across
Deleted: of
Deleted: t
Deleted: f
Deleted: 3
Deleted: U
Deleted: The
Deleted: for the
Deleted: of
Deleted: .
Formatted: Highlight
Formatted: Highlight
Deleted: 15
Deleted: t
Deleted: having
Deleted: a
Deleted: ,
Deleted: and t
Deleted: believe
Deleted: d
Deleted: it was

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 pterygomaxillary fissure, and 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. The authors performed pulsed radiofrequency via the 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, reducing the amount of opioids these patients 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 are both 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 ultrasound imagery, the anesthetic drugs were injected onto the surface of the maxilla. The comparison of the skin sensation of the patients as well as MRI images both 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 is also more comfortable for patients as it does not require the mouth to be open. In-plane

Deleted: .

Deleted: fissura

Deleted: is

Deleted: .

Deleted: ,

Deleted: and t

Deleted: .

Formatted: Highlight

Formatted: Highlight

Deleted: which

Deleted: ed

Formatted: Highlight

Formatted: Highlight

Deleted: were

Deleted: the

Deleted: s

Deleted: of the patients’

Deleted: and the

Deleted: the

Deleted: patients to open their mouths and is, therefore, more comfortable

Deleted: Also, i

technology can also help reduce the difficulty of puncturing. The best way to perform an ultrasound-guided trigeminal nerve block, however, is still unclear. A comparison of the different approaches to ultrasound-guided maxillary nerve blocks is shown in Table 3 and Figure 6.

4 Other Nerves

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

Michalek *et al.* (Michalek et al. 2013) used ultrasound to observe the position of the infraorbital foramen on a skull model. The authors concluded 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. Two other studies (Takechi et al. 2015; Cok et al. 2017) used an 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 studies. The results from another randomized double-blind clinical trial of ultrasound-guided infraorbital nerve blocks suggest that dexmedetomidine combined with bupivacaine have a superior

Deleted: be easily achieved to
Deleted: However, t
Deleted: debated
Deleted: The
Deleted: across
Deleted: of
Deleted: t
Deleted: f
Deleted: 4
Deleted: In the oral and maxillofacial region, apart
Deleted: ,
Deleted: .
Deleted: which means that
Formatted: Highlight
Formatted: Highlight
Deleted: predicted
Deleted: O
Deleted: Cok et al. 2017;
Deleted: the
Deleted: ed
Deleted: gave

analgesic effect than dexamethasone combined with bupivacaine after cleft palate repair surgery (El-Emam & El Motlb 2019).

Deleted: .

Cadaver studies (Spinner & Kirschner 2012) have demonstrated that ultrasound can also be used to guide injection into 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.

Deleted: Supraorbital neuralgia, too, is commonly observed.

Deleted: the

Deleted: to

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Hafeez *et al.* (Hafeez et al. 2014) performed greater palatine nerve blocks with ultrasound guidance with a hockey stick-shaped ultrasound probe in patients and cadavers. They 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 with a more suitable size of ultrasound probe and a more suitable dose of local anesthetics, ultrasound may be used in pre-procedural localization to achieve a successful greater palatine nerve block.

Formatted: Highlight

Formatted: Highlight

Deleted: d

Deleted: under

Deleted: It was

Deleted: a

Deleted: the

Deleted: ,

Deleted: , and ultrasound

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 visualization and guidance of puncture operations. Ultrasound technology has the potential to significantly improve nerve blocks and the treatment of neuralgia.

CONCLUSION

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

Also, ultrasound technology is constantly developing and there have been several suggestions to enhance 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 trials and medical practitioners.

Deleted: the

Deleted: for the

Deleted: In

Deleted: the fields of

Deleted:

Deleted: , ultrasound has a great significance that cannot be underestimated.

Deleted: ,

Deleted: which

Deleted: the

Deleted: the

Deleted: the

Deleted: er

Deleted: e

Deleted: study

Deleted: ed

Deleted: the

Deleted: .

Deleted: studies

Deleted: ACKNOWLEDGMENTS
This study was supported by Sichuan Academic and Technical Leader Training Foundation (2017-A); Sichuan Cadres Health Care Project (2019-901). Research and Develop Program, West China Hospital of Stomatology Sichuan University, (LCYJ2019-1).

Deleted: **CONFLICTS OF INTEREST**

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

REFERENCES

Abdallah FW, Macfarlane AJ, and Brull R. 2016. The Requisites of Needle-to-Nerve Proximity for Ultrasound-Guided Regional Anesthesia: A Scoping Review of the Evidence. *Reg Anesth Pain Med* 41:221-228. 10.1097/aap.0000000000000201

Aggarwal V, Singla M, and Kabi D. 2010. Comparative evaluation of anesthetic efficacy of Gow-Gates mandibular conduction anesthesia, Vazirani-Akinosi technique, buccal-plus-lingual infiltrations, and conventional inferior alveolar nerve anesthesia in patients with irreversible pulpitis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 109:303-308. 10.1016/j.tripleo.2009.09.016

Alfaro-de la Torre P, Boada Pie S, Fajardo Perez M, and Gonzalez-Arnay E. 2019. Ultrasound-guided maxillary nerve block via the pterygopalatine fossa: anterior versus posterior infrazygomatic approach. *Reg Anesth Pain Med*. 10.1136/rapm-2018-100077

Allam AE, Khalil AAF, Eltawab BA, Wu WT, and Chang KV. 2018. Ultrasound-Guided Intervention for Treatment of Trigeminal Neuralgia: An Updated Review of Anatomy and Techniques. *Pain Res Manag* 2018:5480728. 10.1155/2018/5480728

Anugerah A, Nguyen K, and Nader A. 2020. Technical considerations for approaches to the ultrasound-guided maxillary nerve block via the pterygopalatine fossa: a literature review. *Reg Anesth Pain Med* 45:301-305. 10.1136/rapm-2019-100569

Bouzinac A, Tournier JJ, Dao M, and Delbos A. 2014. Ultrasound-guided maxillary nerve block in adults: feasibility and efficiency for postoperative analgesia after maxillary osteotomy. *Minerva Anestesiol* 80:860-861.

Chang KV, Lin CS, Lin CP, Wu WT, and 脰 z 莽 akar L. 2017. Recognition of the Lateral Pterygoid Muscle and Plate during Ultrasound-Guided Trigeminal Nerve Block. *J Clin Diagn Res* 11:Ul01-ul02. 10.7860/jcdr/2017/27724.9932

Chanpong B, Tang R, Sawka A, Krebs C, and Vaghadia H. 2013. Real-time ultrasonographic visualization for guided inferior alveolar nerve injection. *Oral Surg Oral Med Oral Pathol Oral Radiol* 115:272-276. 10.1016/j.oooo.2012.10.019

Chiono J, Raux O, Bringuier S, Sola C, Bigorre M, Capdevila X, and Dadure C. 2014. Bilateral suprazygomatic maxillary nerve block for cleft palate repair in children: a prospective, randomized, double-blind study versus placebo. *Anesthesiology* 120:1362-1369. 10.1097/aln.0000000000000171

Chuang YW, and Chen CH. 2015. Landmark of Ultrasound-Guided Trigeminal Block: Lateral Pterygoid Muscle. *Pain Physician* 18:E933-934.

Cok OY, Deniz S, Eker HE, Oguzkurt L, and Aribogan A. 2017. Management of isolated infraorbital neuralgia by ultrasound-guided infraorbital nerve block with combination of steroid and local anesthetic. *J Clin Anesth* 37:146-148. 10.1016/j.jclinane.2016.12.007

Denny NM, and Harrop-Griffiths W. 2005. Location, location, location! Ultrasound imaging in regional anaesthesia. *Br J Anaesth* 94:1-3. 10.1093/bja/aei001

Echaniz G, Chan V, Maynes JT, Jozaghi Y, and Agur A. 2019. Ultrasound-guided maxillary nerve block: an anatomical study using the suprazygomatic approach. *Can J Anaesth*. 10.1007/s12630-019-01481-x

El-Emam EM, and El Motlb EAA. 2019. Comparative Evaluation of Dexamethasone and Dexmedetomidine as Adjuvants for Bupivacaine in Ultrasound-Guided Infraorbital Nerve Block for Cleft Lip Repair: A Prospective, Randomized, Double-Blind Study. *Anesth Essays Res* 13:354-358. 10.4103/aer.AER_14_19

Hafeez NS, Sondekoppam RV, Ganapathy S, Armstrong JE, Shimizu M, Johnson M, Merrifield P, and Galil KA. 2014. Ultrasound-guided greater palatine nerve block: a case series of anatomical descriptions and clinical evaluations. *Anesth Analg* 119:726-730. 10.1213/ane.0000000000000329

Hannan L, Reader A, Nist R, Beck M, and Meyers WJ. 1999. The use of ultrasound for guiding needle placement for inferior alveolar nerve blocks. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 87:658-665. 10.1016/s1079-2104(99)70156-3

Jain G, Yadav G, Singh AP, Singh Y, and Singh DK. 2016. Efficacy of ultrasound-guided mandibular block in predicting safer anesthetic induction. *Anesth Essays Res* 10:184-188. 10.4103/0259-1162.176406

Kampitak W, and Shibata Y. 2019. Reply to Dr Alfaro-de la Torre et al. *Reg Anesth Pain Med*. 10.1136/rapm-2018-100239

Kampitak W, Tansatit T, and Shibata Y. 2018a. A Cadaveric Study of Ultrasound-Guided Maxillary Nerve Block Via the Pterygopalatine Fossa: A Novel Technique Using the Lateral Pterygoid Plate Approach. *Reg Anesth Pain Med* 43:625-630. 10.1097/aap.0000000000000790

Kampitak W, Tansatit T, and Shibata Y. 2018b. A Novel Technique of Ultrasound-Guided Selective Mandibular Nerve Block With a Lateral Pterygoid Plate Approach: A Cadaveric Study. *Reg Anesth Pain Med* 43:763-767. 10.1097/aap.0000000000000760

Kojima Y, Murouchi T, Akiba M, and Oka T. 2020. Ultrasound-guided inferior alveolar nerve block for postoperative analgesia after mandibular sequestrectomy: A single-center retrospective study. *J Clin Anesth* 60:39-40. 10.1016/j.jclinane.2019.08.026

Kumar A, Sinha C, Kumar A, Kumari P, and Mukul SK. 2018. Ultrasound-guided trigeminal nerve block and its comparison with conventional analgesics in patients undergoing faciomaxillary surgery: Randomised control trial. *Indian J Anaesth* 62:871-875. 10.4103/ija.IJA_256_18

Kumita S, Murouchi T, and Arakawa J. 2017. Ultrasound-guided maxillary and inferior alveolar nerve blocks for postoperative analgesia in gnathoplasty. *Asian J Anesthesiol* 55:89-90. 10.1016/j.aja.2017.11.001

Luo F, Lu J, and Ji N. 2018. Treatment of Refractory Idiopathic Supraorbital Neuralgia Using Percutaneous Pulsed Radiofrequency. *Pain Practice* 18.

Michalek P, Donaldson W, McAleavey F, Johnston P, and Kiska R. 2013. Ultrasound imaging of the infraorbital foramen and simulation of the ultrasound-guided infraorbital nerve block using a skull model. *Surg Radiol Anat* 35:319-322. 10.1007/s00276-012-1039-3

Milani AS, Froughreyhani M, Rahimi S, Zand V, and Jafarabadi MA. Volume of Anesthetic Agents and IANB Success: A Systematic Review. *Anesth Prog* 65:16-23. 10.2344/anpr-65-01-03

Moher D, Liberati A, Tetzlaff J, and Altman DG. 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 6:e1000097. 10.1371/journal.pmed.1000097

Nader A, Bendok BR, Prine JJ, and Kendall MC. 2015. Ultrasound-Guided Pulsed Radiofrequency Application via the Pterygopalatine Fossa: A Practical Approach to Treat Refractory Trigeminal Neuralgia. *Pain Physician* 18:E411-415.

Nader A, Kendall MC, De Oliveria GS, Chen JQ, Vanderby B, Rosenow JM, and Bendok BR. 2013a. Ultrasound-guided trigeminal nerve block via the pterygopalatine fossa: an effective treatment for trigeminal neuralgia and atypical facial pain. *Pain Physician* 16:E537-545.

Nader A, Schittek H, and Kendall MC. 2013b. Lateral pterygoid muscle and maxillary artery are key anatomical landmarks for ultrasound-guided trigeminal nerve block. *Anesthesiology* 118:957. 10.1097/ALN.0b013e31826d3dfc

O'Donnell BD, and Loughnane F. 2019. Novel nerve imaging and regional anesthesia, bio-impedance and the future. *Best Pract Res Clin Anaesthesiol* 33:23-35. 10.1016/j.bpa.2019.02.001

Potocnik I, and Bajrovic F. 1999. Failure of inferior alveolar nerve block in endodontics. *Endod Dent Traumatol* 15:247-251. 10.1111/j.1600-9657.1999.tb00782.x

Prabhu Nakkeeran K, Ravi P, Doss GT, and Raja KK. 2019. Is the Vazirani-Akinosi Nerve Block a Better Technique Than the Conventional Inferior Alveolar Nerve Block for Beginners? *J Oral Maxillofac Surg* 77:489-492. 10.1016/j.joms.2018.08.034

Ren H, Shen Y, and Luo F. 2020. Treatment of Supraorbital Neuralgia Using Ultrasound-Guided Radiofrequency Thermocoagulation of the Supraorbital Nerve: A Retrospective Study. *J Pain Res* 13:251-259. 10.2147/jpr.S228720

Sola C, Raux O, Savath L, Macq C, Capdevila X, and Dadure C. 2012. Ultrasound guidance characteristics and efficiency of suprazygomatic maxillary nerve blocks in infants: a descriptive prospective study. *Paediatr Anaesth* 22:841-846. 10.1111/j.1460-9592.2012.03861.x

Spinner D, and Kirschner JS. 2012. Accuracy of ultrasound-guided superficial trigeminal nerve blocks using methylene blue in cadavers. *Pain Med* 13:1469-1473. 10.1111/j.1526-4637.2012.01480.x

Takahashi H, and Suzuki T. 2017. A novel approach for performing ultrasound-guided maxillary nerve block. *J Clin Anesth* 43:61-62. 10.1016/j.jclinane.2017.09.015

Takahashi H, and Suzuki T. 2018. A modified anterior approach for ultrasound-guided maxillary nerve block and its application to the mandibular nerve block. *J Clin Anesth* 46:96-98. 10.1016/j.jclinane.2018.01.015

Takechi K, Konishi A, Kikuchi K, Fujioka S, Fujii T, Yorozuya T, Kuzume K, and Nagaro T. 2015. Real-time ultrasound-guided infraorbital nerve block to treat trigeminal neuralgia using a high concentration of tetracaine dissolved in bupivacaine. *Scand J Pain* 6:51-54. 10.1016/j.sjpain.2014.10.003

Tsuchiya M, Mizutani K, Yabe M, Mori T, and Ueda W. 2019. Ultrasound-guided mandibular nerve block with local anesthetic and low-molecular weight dextran helps reduce anesthetic requirements for parotidectomy. *Minerva Anestesiol* 85:202-203. 10.23736/s0375-9393.18.12966-x

Ying YL, and Du DP. 2017. Introduction of Another Approach of Ultrasound-Guided Maxillary Nerve Block via Pterygopalatine Fossa. *Journal of Clinical & Diagnostic Research* 11.

Zou F, Gong W, Zhang D, and Fan K. 2020. A novel approach for performing ultrasound-guided trigeminal nerve block: Above the zygomatic arch. *J Clin Anesth* 60:36-38. 10.1016/j.jclinane.2019.08.028

Figure captions

Figure 1: Application of ultrasound in the oral and maxillofacial region. (A) Ultrasound Diagnostic System. (B) Ultrasonic scaler tip. (C) Ultrasound used to scan and diagnose the examination site. (D) Ultrasound guided puncture operation. (E) Ultrasound thermo-chemotherapy. (F) Ultrasonic scaling. (G) Ultrasonic root canal irrigation.

Deleted: at

Formatted: Font colour: Red

Deleted: Use u

Figure 2: Study selection process.

Figure 3: 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 where 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 the pterygopalatine fossa.

Deleted: 1

Deleted: ,

Deleted: ,

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.

Figure 4: The needle position of different methods of performing an ultrasound-guided mandibular nerve block in extraoral approach with mouth opened

Deleted: 2

Deleted: in

Deleted: to

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 in the infrazygomatic approach described by Kampitak et al.

Deleted: through

Figure 5: (A) The needle position of different methods of performing an 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: the suprazygomatic approach described by Sola et al; 2: the coracoid approach of the infrazygomatic approach described by Takahashi et al. (B) The needle position of different methods of performing an ultrasound-guided maxillary nerve block while the mouth is opened. 3: Posterior approach of the infrazygomatic approach described by Nader et al. where the mouth is slightly opened; 4: Anterior approach of the infrazygomatic approach described by Kampitak et al. in which the anterior edge of LPP is used as the landmark for puncturing.

Deleted: e3

Deleted: in

Deleted: to

Deleted: S

Deleted: C

Deleted: in

Deleted: to

Deleted: ,

Deleted: regarded

Deleted: of

Figure 6: The needle position of different methods of performing an ultrasound-guided Trigeminal Ganglion block.

Deleted: 4

Deleted: in

Deleted: to

Studies describe that an injection into the pterygopalatine fossa can make the anesthetic

Deleted: It is described in s

Deleted: the

drugs diffuse through the foramen rotundum to the middle cranial fossa, thereby blocking three branches of the trigeminal nerve.

1: The infrazygomatic approach described by Nader et al.

2: The suprazygomatic approach described by Zou et al.

Table captions

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

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

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

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

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

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

Page 5: [1] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [1] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [1] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [1] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [1] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [1] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [1] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [1] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [1] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [1] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [2] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [2] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [2] Deleted Marel Stock 15/09/2021 11:36:00

Page 5: [2] Deleted   Marel Stock   15/09/2021 11:36:00

Page 5: [2] Deleted   Marel Stock   15/09/2021 11:36:00

Page 5: [2] Deleted   Marel Stock   15/09/2021 11:36:00

Page 5: [3] Deleted   Tsao X   31/08/2021 23:01:00

Page 5: [4] Deleted   Marel Stock   15/09/2021 11:46:00