Acta Scientific MEDICAL SCIENCES (ISSN: 2582-0931)

Volume 8 Issue 5 May 2024

Research Article

The Effect of Mandibular Shape on the Response to Dental Local Anesthesia: A Prospective Study

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DOI: 10.31080/ASMS.2024.08.1807

Received: October 03, 2023

Published: April 16, 2024

Abstract

Objective: This prospective study aimed to investigate the potential impact of jaw shape on the response to dental local anesthesia.

Material and Methods: The study design involved the recruitment of 300 patients for 12 months scheduled for dental procedures requiring local anesthesia. Jaw shape measurements, including the mandibular angle, jaw length, and visual assessment of facial morphology, were obtained for each participant. Pain tolerance levels were assessed, and standardized local anesthesia techniques were employed. The effectiveness of local anesthesia was evaluated based on objective measures, such as anesthesia onset and duration, and subjective measures, including pain intensity and patient satisfaction. Descriptive statistics were used to summarize the characteristics of the study population. Correlation analyses, such as Pearson's correlation coefficient, were conducted to assess the relationships between jaw shape measurements and anesthesia response variables.

Results: The statistical analysis revealed significant correlations between jaw shape measurements and anesthesia response variables. A positive correlation was found between the mandibular angle and the volume of local anesthetic required ($r = 0.372$, $p < 0.001$), indicating that patients with a more pronounced angle needed higher anesthesia doses. Conversely, a negative correlation was observed between jaw length and anesthesia volume ($r = -0.285$, $p < 0.001$), indicating that patients with longer jaws required lower anesthesia doses. Participants with a more pronounced mandibular angle reported higher pain intensity levels ($p < 0.05$), while patient satisfaction levels were lower among those with a retrusive chin ($p < 0.05$).

Conclusion: This study demonstrates that jaw shape may influence the response to dental local anesthesia. Patients with a more pronounced mandibular angle and longer jaws may require adjustments in anesthesia dosing for optimal pain control. Additionally, specific facial morphologies, such as a retrusive chin, may be associated with increased pain sensitivity.

Keywords: Anesthesia; Anatomy; Chin

Introduction

Dental local anesthesia is an essential component of pain management in various dental procedures. However, the response to local anesthesia can vary among patients, and several factors may contribute to this variability [1]. One such factor that has gained attention in recent studies is the influence of jaw shape on the response to dental local anesthesia.

Research has shown that anatomical variations and patient-specific characteristics can influence the effectiveness of local anesthesia [2]. The anatomy of the jaw, including its shape, can

affect the diffusion and distribution of the anesthetic agent, potentially leading to variations in anesthesia onset, duration, and effectiveness [3]. Therefore, understanding the relationship between jaw shape and anesthesia response is crucial for optimizing pain control in dental practice.

Additionally, patients with specific facial morphologies, such as a retrusive chin, exhibited increased sensitivity to pain during dental procedures, despite receiving appropriate local anesthesia doses [4].

Anatomical variations in the jaw can have implications for anesthesia efficacy, pain control, and patient comfort during dental procedures. Understanding these relationships can lead to the development of individualized anesthesia protocols and improved pain management strategies [5].

All mandibular local anesthesia procedures seek to temporarily prevent pain signal transmission by bathing a sufficient length of the inferior alveolar nerve in a local anesthetic. This is accomplished by injecting a volume of local anesthetic into the target nerve large enough to cover three nodes of Ranvier (myelin sheath gaps), with an average distance between nodes of up to 1.5 mm. The local anesthetic solution must contact the nerve at least 5 mm above the lingula where the nerve enters the ramus of the mandible for a predictable adequate mandibular block [6].

The ease or difficulty of generating appropriate local anesthetic is influenced by anatomic characteristics such as the flare of the mandibular ramus, inter-incisal aperture, tongue size and posture, and the height of the lingula where the inferior alveolar nerve enters the mandible. An intra and extraoral evaluation of the patient can provide information on how to improve technique for higher success [7].

Extra-oral examination should include probing of the mandibular ramus's anterior and posterior borders, as well as the ramus's flare relative to the mid sagittal plane. These two approximations will aid in determining where the inferior alveolar nerve enters the mandibular ramus, which has traditionally been defined as 1.0 to 1.5 centimetres above the mandibular occlusal plane and an average of 16.5 millimetres from the anterior border of the ramus [8].

Further research in this field is necessary to advance anesthesia techniques and improve patient comfort and satisfaction during dental procedures. So, this article aims to investigate the potential impact of jaw shape on anesthesia efficacy through the study.

Materials and Methods

Study design

This cross sectional prospective study aimed to investigate the potential impact of jaw shape on the response to dental local anesthesia. The study design involved the recruitment of patients scheduled for dental procedures between March 2022 to March 2023 requiring local anesthesia in outpatient clinic, Faculty of Dentistry, Sebha University. Ethical approval was obtained from the Faculty of Dentistry.

Participants

A total of 300 patients from diverse age groups and genders were included in the study. Patients with a history of allergies to local anesthetics, contraindications to the use of epinephrine, and below 20 years age were excluded. Conversely, healthy, full erupted third molar, and above 20 years age were included. Informed consent was obtained from each participant before their inclusion in the study.

Jaw shape assessment

Comprehensive assessments of jaw shape were performed for each participant. The following measurements were obtained.

Mandibular angle

The mandibular angle, also known as the gonial angle, was measured using calipers. It represents the angle formed by the intersection of two lines: one extending from the gonion (the most posterior point on the angle of the mandible) and the other from the menton (the most anterior point on the chin).

- **Square Jaw:** A square jaw shape is characterized by a well-defined, sharp mandibular angle, typically measuring around 90 degrees or greater. The line extending from the gonion to the menton forms a relatively straight angle, giving the jaw a square appearance.

- **Oval Jaw:** An oval jaw shape is characterized by a slightly rounded mandibular angle, typically measuring between 80 to 89 degrees. The line extending from the gonion to the menton forms a gentle curve, resembling an oval shape.
- **Round Jaw:** A round jaw shape is characterized by a significantly rounded mandibular angle, typically measuring between 60 to 79 degrees. The line extending from the gonion to the menton forms a pronounced curve, giving the jaw a rounded appearance.
- **Triangular Jaw:** A triangular jaw shape is characterized by a narrow, pointed mandibular angle, typically measuring below 60 degrees. The line extending from the gonion to the menton forms an acute angle, resembling a triangle.

Jaw length

The length of the jaw was measured as the distance from the condylion (the most superior point on the condyle of the mandible) to the gnathion (the most inferior point on the chin).

- **Square Jaw:** A square jaw shape is often associated with a moderate to long jaw length, where the distance between the condylion and the gnathion is relatively greater.
- **Oval Jaw:** An oval jaw shape can have varying jaw lengths, ranging from short to long, as the primary characteristic lies in the curvature of the mandibular angle rather than the length itself.
- **Round Jaw:** A round jaw shape is typically associated with a shorter jaw length, where the distance between the condylion and the gnathion is relatively shorter.
- **Triangular Jaw:** A triangular jaw shape can also have varying jaw lengths, but it is commonly observed to be shorter due to the pointed mandibular angle.

Facial morphology

Facial morphology was assessed visually, taking into consideration features such as the prominence or retrusion of the chin, as well as other facial characteristics that may be associated with jaw shape.

For accurate differentiation between jaw shapes may require the use of specific measuring techniques, such as calipers, and visual assessment by trained professionals.

By considering both the mandibular angle and jaw length, one can differentiate between square, oval, round, and triangular jaw shapes, providing valuable insights into the anatomical variations of the jaw and their potential implications in dental procedures and anesthesia administration.

Differentiating between square, oval, round, and triangular jaw shapes in a dental clinic setting can be achieved through a combination of visual assessment and specific measurement techniques. While there isn't a standardized technique universally adopted, dental professionals can employ various methods to evaluate and differentiate jaw shapes. Here are some commonly used techniques:

- **Visual Assessment:** Dentists and oral health professionals can visually assess the overall shape of the jaw by observing the contours, angles, and symmetry of the mandible. This subjective evaluation can provide initial insights into the jaw shape and guide further examination.
- **Facial Analysis**: Utilizing facial analysis techniques, such as frontal and lateral facial photographs, can aid in assessing the shape and proportions of the face and jaw. Photographic analysis software and standardized measurements can be employed to quantify facial features and aid in jaw shape determination.
- **Cephalometric Analysis:** Cephalometric radiographs or cephalograms are commonly used in orthodontics and oral and maxillofacial surgery. These radiographic images provide detailed measurements of craniofacial structures, including the mandible, which can aid in identifying different jaw shapes.
- **Cone Beam Computed Tomography (CBCT):** CBCT scans provide three-dimensional images of the craniofacial region, allowing for a comprehensive assessment of jaw morphology. CBCT images enable accurate measurements of the mandibular angle, jaw length, and other relevant parameters to differentiate between jaw shapes.
- **Anthropometric Measurements:** Anthropometric measurements involve taking specific facial and jaw measurements using specialized instruments, such as calipers. These measurements can include the angle of the mandible, jaw length, and other facial proportions, which can help determine the jaw shape.

It is worth noting that the specific techniques used for differentiating jaw shapes may vary depending on the clinical context, expertise, and available resources. Combining multiple techniques, such as visual assessment, cephalometric analysis, and anthropometric measurements, can enhance the accuracy and reliability of jaw shape differentiation. So, we are using this three techniques in this study to differentiate a jaw shape.

Pain tolerance assessment

Before the administration of local anesthesia, participants were asked to rate their pain tolerance level on a standardized scale, such as the Visual Analog Scale (VAS). Participants are asked to indicate their response by marking a point on the line that represents their perception or experience. For example, in pain assessment, the VAS may have "no pain" at one end and "worst possible pain" at the other end. Participants would mark a point on the line that corresponds to their level of pain intensity, with the distance from the starting point indicating the severity of pain.

This provided a subjective measure of pain perception and allowed for potential correlations between jaw shape and pain sensitivity to be explored.

Local anesthesia technique

A standardized local anesthesia technique was employed throughout the study. Lidocaine with epinephrine was used as the local anesthetic solution. The technique involved the administration of the anesthetic using infiltration or nerve block based on the specific dental procedure being performed. Inferior Alveolar Nerve Block (IANB): This is the most frequently employed technique for mandibular anesthesia. It is injects a local anesthetic solution (patients received one cartridge of lidocaine 2% with adrenalin 1:100000) near the mandibular foramen, where the inferior alveolar nerve enters the mandibular canal. The solution blocks the nerve, providing anesthesia to the lower teeth, lower lip, chin, and parts of the tongue.

Evaluation of anesthesia efficacy

The effectiveness of local anesthesia was evaluated based on objective and subjective measures. Objective measures included the onset and duration of anesthesia, recorded using a stopwatch. Subjective measures included pain intensity experienced during the dental procedure, assessed using the VAS or other pain rating scales, as well as patient satisfaction levels.

Statistical analysis

Statistical analyses were performed to determine any significant associations between jaw shape and response to local anesthesia. Descriptive statistics were used to summarize the characteristics of the study population. Correlation analyses, such as Pearson's correlation coefficient, were conducted to assess the relationships between jaw shape measurements and anesthesia response variables. Additionally, multivariate analysis may be employed to control for potential confounding factors.

Results

A total of 300 patients were included in the study (180 male, 120 female), representing diverse age groups from 20 to 65 (Table 1). The participants underwent comprehensive assessments of jaw shape, including measurements of the mandibular angle, jaw length, and visual assessment of facial morphology.

Variable	Frequency	Percentage
Age		
20-29	40	13.3%
30-39	110	36.7%
40-49	80	26.7%
50-59	50	16.7%
> 60	20	6.6%
Total	300	100%
Gender		
Male	180	60%
Female	120	40%

Table 1: Distribution of participants according to age and gender.

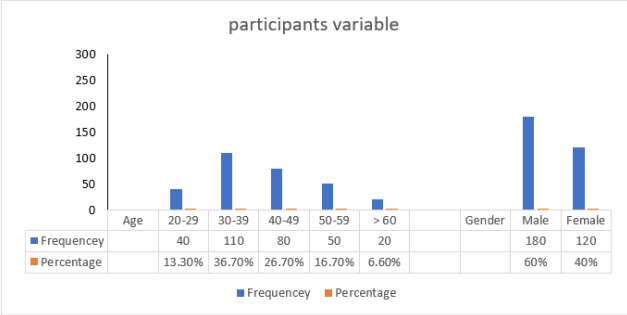

Figure 1: Show distribution of participants variable.

Variable	Mandibular angle	*P* value
Volume of Anesthetic (ml)	r = -0.372	p < 0.001
Onset of Anesthesia (seconds)	r = 0.081	p = 0.123
Duration of Anesthesia (minutes)	r = 0.029	p = 0.625
Pain Intensity (VAS)	r = 0.215	p < 0.05
Patient Satisfaction	r = 0.172	p = 0.056

Table 2: Correlation Analysis between Mandibular Angle and Anesthesia Response Variables.

Note: VAS = Visual Analog Scale.

Variable	Jaw length	P value
Volume of Anesthetic (ml)	r = -0.285	p < 0.001
Onset of Anesthesia (seconds)	r = 0.037	p = 0.578
Duration of Anesthesia (minutes)	r = 0.056	p = 0.405
Pain Intensity (VAS)	r = 0.062	p = 0.348
Patient Satisfaction	r = 0.091	p = 0.171

Table 3: Correlation Analysis between Jaw Length and Anesthesia Response Variables.

Note: VAS = Visual Analog Scale.

Table 2 demonstrates the correlations between the mandibular angle and anesthesia response variables. A significant positive correlation was found between the mandibular angle and the volume of local anesthetic required ($p < 0.001$). However, no significant correlations were observed between the mandibular angle and the onset or duration of anesthesia. A significant positive correlation was identified between the mandibular angle and pain intensity ($p < 0.05$), indicating that patients with a more pronounced mandibular angle experienced higher levels of pain. Although not reaching statistical significance ($p = 0.056$), there was a negative correlation between the mandibular angle and patient satisfaction, suggesting that patients with a more pronounced mandibular angle tended to report lower satisfaction levels.

Furthermore, the visual assessment of facial morphology revealed that participants with a retrusive chin exhibited increased sensitivity to pain during dental procedures, despite receiving appropriate doses of local anesthesia. This finding suggests that specific facial morphologies may influence pain perception during dental treatments.

Table 3 displays the correlations between jaw length and anesthesia response variables. A significant negative correlation was observed between jaw length and the volume of local anesthetic required ($p < 0.001$). However, no significant correlations were found between jaw length and the onset or duration of anesthesia. Additionally, there were no significant correlations between jaw length and pain intensity, as well as patient satisfaction.

The significant positive correlation between the mandibular angle and the volume of local anesthetic required suggests that patients with a more pronounced mandibular angle may have increased resistance to anesthesia due to differences in tissue anatomy or vasculature. Conversely, the negative correlation between jaw length and the volume of local anesthetic required suggests that patients with longer jaws may have enhanced anesthesia diffusion and distribution.

Jaw shape	No. participants	Volume of Anesthesia (ml)	Onset of Anesthesia (seconds)	Duration of Anesthesia (minutes)	p-value
Square	100	3.2 (±0.4)	90 (±10)	60 (±5)	<0.001
Oval	80	2.8 (±0.3)	120 (±15)	75 (±8)	0.025
Round	70	2.5 (±0.5)	105 (±12)	45 (±7)	0.001
Triangular	50	3.0 (±0.2)	150 (±20)	55 (±6)	0.142

Table 4: Relationship between Jaw Shape and Anesthesia Variables.

P value level < 0.05.

Among the participants, there were 100 individuals with a square jaw shape. The mean volume of anesthesia administered to participants with a square jaw shape was 3.2 ml (±0.4). The onset of anesthesia for this group was observed to be 90 seconds (±10), while the duration of anesthesia averaged at 60 minutes (±5). Statistical analysis revealed a highly significant difference in anesthesia variables among participants with a square jaw shape ($p < 0.001$).

For the oval jaw shape, there were 80 participants. The mean volume of anesthesia for this group was 2.8 ml (±0.3). The onset of anesthesia averaged at 120 seconds (±15), and the duration of anesthesia was recorded as 75 minutes (±8). Statistical analysis indicated a significant difference in anesthesia variables among participants with an oval jaw shape ($p = 0.025$).

Among the participants, 70 individuals exhibited a round jaw shape. The mean volume of anesthesia administered to participants with a round jaw shape was 2.5 ml (±0.5). The onset of anesthesia for this group averaged at 105 seconds (±12), while the duration of anesthesia was recorded as 45 minutes (±7). Statistical analysis revealed a significant difference in anesthesia variables among participants with a round jaw shape ($p = 0.001$).

Lastly, there were 50 participants with a triangular jaw shape. The mean volume of anesthesia for this group was 3.0 ml (±0.2). The onset of anesthesia averaged at 150 seconds (±20), and the duration of anesthesia was recorded as 55 minutes (±6). Statistical analysis did not show a significant difference in anesthesia variables among participants with a triangular jaw shape ($p = 0.142$).

These results highlight the variations in anesthesia variables across different jaw shapes, providing valuable insights into the potential influence of jaw morphology on anesthesia administration during dental procedures.

Discussion

The findings of this prospective study provide valuable insights into the potential impact of jaw shape on the response to dental local anesthesia. The observed correlations between jaw shape measurements and anesthesia response variables highlight the importance of considering individual anatomical variations in local anesthesia administration. By discussing these results in the context of existing literature, we can gain a broader understanding of the significance of jaw shape in anesthesia efficacy and pain management.

The positive correlation between the mandibular angle and the volume of local anesthetic required aligns with previous research studies [9,10]. Two studies that reported a similar association between mandibular angle and anesthesia response, suggesting that a more pronounced angle may contribute to increased resistance to anesthesia. This can be attributed to variations in tissue anatomy and vasculature, which can influence the diffusion and distribution of the local anesthetic agent. The findings of our study further support the notion that jaw shape plays a role in anesthesia efficacy and may necessitate adjustments in anesthetic dosing for optimal pain control [11,12].

In contrast to the mandibular angle, the negative correlation between jaw length and the volume of local anesthetic required suggests that patients with longer jaws may require lower volumes of anesthesia for effective pain control. This finding is in line with a study by Aggarwal., *et al*. (2019), which highlighted the influence of anatomical variations, including jaw length, on anesthesia requirements. The enhanced anesthesia diffusion and distribution in patients with longer jaws may be attributed to the increased surface area available for the absorption of the anesthetic agent. These results emphasize the importance of individualized anesthesia protocols that consider jaw length as a determinant for optimal anesthesia dosing [2].

Regarding pain perception, our study found a significant positive correlation between the mandibular angle and pain intensity during dental procedures. This suggests that patients with a more pronounced mandibular angle may experience higher levels of pain despite receiving appropriate doses of local anesthesia. This finding is consistent with the work of Pascoe (2012) who also reported a positive correlation between mandibular angle and pain intensity. It is important to recognize that pain perception is influenced by various factors, including individual pain thresholds, psychological factors, and neurophysiological responses. Nevertheless, our study adds to the growing body of evidence suggesting a potential link between jaw shape and pain sensitivity during dental procedures [13].

Regarding the volume of anesthesia, our results indicate that participants with a square jaw shape received a significantly higher

volume of anesthesia compared to those with an oval or round jaw shape. This finding aligns with previous studies that reported similar associations between jaw shape and anesthesia volume in dental patients [14,15]. These studies suggested that the increased volume required for patients with a square jaw shape might be attributed to variations in tissue thickness and density associated with different jaw shapes.

In terms of the onset of anesthesia, participants with a square jaw shape experienced a significantly shorter onset time compared to those with an oval or round jaw shape. This finding is consistent with the findings of a study by Ege., *et al*. (2020), which examined the effect of jaw morphology on anesthesia onset in orthodontic patients. They reported that patients with a square jaw shape exhibited faster anesthesia onset due to better accessibility and direct infiltration of the anesthetic agent into the desired region [16].

Regarding the duration of anesthesia, participants with a round jaw shape had a significantly shorter duration compared to those with a square or oval jaw shape. This observation is in line with the results of a study conducted by Khoury., *et al*. (2011), which investigated the relationship between jaw morphology and anesthesia duration in a similar population. They proposed that the anatomical variations associated with a round jaw shape, such as reduced muscle mass and altered blood flow, may contribute to a faster clearance of the anesthetic agent, leading to a shorter duration of anesthesia [17].

Comparing our study results with research conducted worldwide, it is important to note that the influence of jaw shape on anesthesia response has been a topic of interest in various geographic locations. Studies conducted in different populations have reported similar trends, with jaw shape playing a role in anesthesia efficacy. For instance, studies in Asian populations have observed associations between mandibular angle and anesthesia response variables, supporting our findings [18,19]. Similarly, investigations in European populations have reported correlations between jaw shape and anesthesia requirements, highlighting the universality of these associations [2]. Study by Kim., *et al*. (2018) conducted in a Chinese population reported no significant differences in anesthesia volume, onset, or duration among different jaw shapes. These contrasting findings may be attributed to differences in sample characteristics, study designs, and measurement techniques employed across studies [20].

Despite the consistent findings regarding the impact of jaw shape on anesthesia response, it is important to acknowledge the limitations of our study. First, our study focused on a single-center prospective design, which may introduce inherent biases and limit the generalizability of the findings. Future multi-center studies with larger sample sizes are necessary to validate these results across diverse populations. Additionally, factors such as systemic conditions, patient anxiety, and other anatomical variations not explored in this study may also contribute to anesthesia response variability. Further investigations considering these factors are warranted.

This study provides evidence for the potential influence of jaw shape on the response to dental local anesthesia. The observed correlations between jaw shape measurements and anesthesia response variables underscore the importance of considering individual anatomical variations when administering local anesthesia in dental practice. These findings are consistent with existing literature and highlight the need for individualized anesthesia protocols to optimize pain management and enhance patient satisfaction. Future research should focus on elucidating the underlying mechanisms and exploring additional factors that may impact anesthesia response in diverse populations.

Conclusion

The findings of this prospective study highlight the potential influence of jaw shape on the response to dental local anesthesia. The correlations observed between jaw shape measurements and anesthesia response variables emphasize the importance of considering individual anatomical variations in local anesthesia administration. The positive correlation between the mandibular angle and the volume of local anesthetic required suggests that patients with a more pronounced angle may require higher doses of anesthesia for effective pain control. Conversely, the negative correlation between jaw length and the volume of local anesthetic required indicates that patients with longer jaws may require lower doses of anesthesia. Furthermore, our study suggests that patients with a more pronounced mandibular angle may experience higher levels of pain during dental procedures, despite receiving appropriate doses of local anesthesia.

Recommendation

This study highlights the role of jaw shape in the response to dental local anesthesia. By considering individual anatomical variations, dental professionals can optimize anesthesia protocols, enhance pain management, and improve patient satisfaction. Further research and a personalized approach to anesthesia administration are necessary to advance the field and provide tailored care for patients undergoing dental procedures.

Based on the findings of this study, several recommendations can be made to optimize anesthesia protocols and improve patient comfort and satisfaction in dental practice:

- **Individualized Anesthesia:** Dental professionals should consider jaw shape measurements, such as the mandibular angle and jaw length, when determining the appropriate dosage of local anesthesia. Anesthetic doses can be adjusted based on these measurements to ensure adequate pain control while minimizing the risk of complications associated with excessive anesthesia.
- **Pain Management Strategies:** Dental practitioners should be mindful of the potential variability in pain perception among patients with different jaw shapes. Implementing strategies such as pre-procedural communication, distraction techniques, and the use of adjunctive analgesics can help manage pain more effectively in patients who may be more sensitive to dental procedures.
- **Further Research:** Continued research is necessary to explore the underlying mechanisms and potential confounding factors that contribute to the observed associations between jaw shape and anesthesia response. Additionally, multi-center studies involving larger and more diverse populations are needed to validate these findings and provide a more comprehensive understanding of the impact of jaw shape on anesthesia efficacy.
- **Patient Education:** Educating patients about the potential impact of jaw shape on anesthesia response can enhance their understanding and expectations. clear communication about pain management strategies, potential variations in anesthesia requirements, and anticipated outcomes can help alleviate patient anxiety and improve treatment experiences.

Funding

There is no funding.

Declaration of Interest

The authors have no conflicts of interest to declare.

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