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ORIGINAL ARTICLE

Exploring the pterygopalatine fossa: a comprehensive radiological analysis for advancing maxillofacial therapeutics

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ABSTRACT

Objectives: The purpose of the study is to analyze whether the volume of the pterygopalatine fossa will have a significant impact on the qualitative effect of local anesthesia or any other therapeutic procedures through this structure.

Materials and Methods: It is a descriptive retrospective study with a single institutional setting. The study included subjects of age above 18 with quality cone beam computed tomography (CBCT) images taken from 2020 to 2023. Descriptive statistics were performed. Volume and sex associations were done through an independent t test, and volume and age associations were done through a Chi-square test. A P value of less than 0.05 was considered significant.

Results: A study of 107 patients, excluding 53 females and 54 males, found a significant difference in the mean volumes of the pterygopalatine fossa (PPF) between males and females. The average capacity was 717±66.7 cc on the right side and 661±61.6 cc on the left, with a p value less than 0.001.

Conclusion: Accurately assessing the volumetric capacity of the PPF is crucial for local anaesthetic and other therapeutic applications. Males have a significantly larger volume of PPF than females, and semiautomatic CBCT picture segmentation offers a practical and independently tested method.

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KEY WORDS
Pterygopalatine fossa, Cone Beam Computed Tomography, Morphology, Local anesthesia, Trigeminal neuralgia

Introduction

The middle cranial fossa of the human skull has a restricted, pyramid-shaped compartment identified as the pterygopalatine fossa. Positioned behind the maxilla and beneath the sphenoid bone, this anatomical structure plays a crucial role in housing and facilitating the function of several important nerves and blood vessels. It serves as a critical crossroads for various sensory and autonomic nerves that are responsible for functions such as taste, salivation, and the control of blood vessels in the head. Additionally, the pterygopalatine fossa is connected to the nasal cavity, making it significant in the management of nasal congestion and the drainage of mucus. Overall, this fossa's intricate anatomy and functions make it a central hub for various processes related to the head and face (1).

The pterygopalatine fossa (PPF) holds significant dental implications due to its close proximity to the maxillary teeth and its connections with various nerves and blood vessels. Dentists and oral surgeons must be aware of its importance when performing procedures such as maxillary nerve blocks for pain management during dental work (2).The maxillary nerve (V2), a subsidiary of the trigeminal nerve that innervates the upper teeth along with adjacent structures, is distributed predominantly through this fossa. Dentists often perform a maxillary nerve block by delivering local anesthetic agents into the pterygopalatine fossa, effectively numbing the maxillary dental region. This technique is instrumental in ensuring patient comfort during various dental treatments, such as extractions, root canal procedures, or orthodontic work. Understanding the anatomy and the precise administration of local anesthesia within the pterygopalatine fossa is a fundamental skill for dental professionals, as it can greatly enhance the patient's experience and the success of dental procedures in this area (3).

Cone-beam computed tomography (CBCT) has revolutionized the imaging of the pterygomandibular fossa, providing valuable insights for dental professionals. This imaging technique offers a three-dimensional view of the pterygomandibular fossa, which is particularly beneficial in the context of oral and maxillofacial surgery. CBCT allows for precise visualization of the anatomical structures in and around the pterygomandibular fossa. This detailed imaging is essential for planning dental implant placements, extractions, or other surgical procedures, as it helps clinicians avoid potential nerve damage, assess the feasibility of treatments, and ensure optimal outcomes (4). By offering accurate and comprehensive views of the pterygomandibular fossa, CBCT has become an invaluable tool in modern dentistry, improving patient care and safety. Hence, this study aims to volumetrically analyze the pterygopalatine fossa, which can provide useful insights in maxillofacial surgery.

Materials And Methods

The Institutional Ethical Board conferred ethical approval for this observational study, which was carried out in the Department of Oral Medicine and Radiology from December 2022 to April 2023. The sample size was calculated to be 107 through the manual method. The antiquated CBCT images that fulfilled the requirements for the retrospective component were provided by the Department of Oral Medicine and Radiology.

Inclusion criteria:

• The scan should involve the alveolar crest, the entire sinus, and up to the supraorbital margin.

•Good quality CBCT scan

Exclusion criteria:

Facial trauma involving the maxillary sinus and sphenoid sinus, sinusoidal pathologies, bone diseases affecting the maxillary sinus, syndromes and developmental defects.

Methodology

Radiographs satisfying the inclusion criteria were sub-

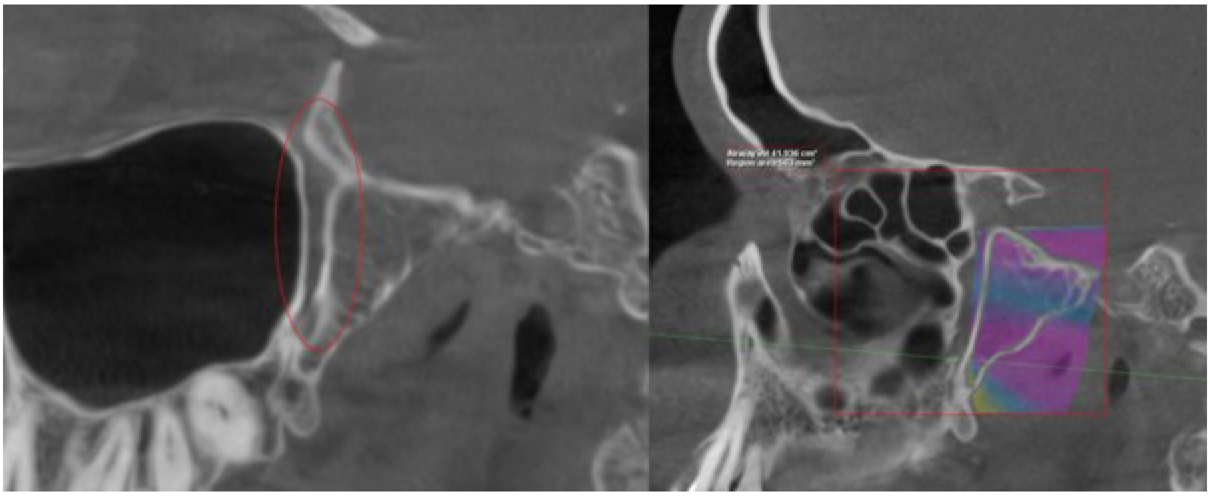

Figure 1: Semi-automatic segmentation of pterygopalatine fossa

jected to analysis for the following landmarks in axial, coronal, sagittal, and 3D-rendered images in Planmeca Romexis 5.3 (3D software). Semiautomated segmentation was employed for locating and defining the PPF. For the purpose of ensuring accurate segmentation, manual segmentation was subsequently carried out. This program instinctively determined the PPF's volume in cubic millimeters. The manual, semiautomatic, and automatic approaches form the foundation of this technique. Semiautomatic segmentation is used extensively because it combines the accuracy and reproducibility of manual segmentation with the efficiency and constancy of automated segmentation (Figure 1).

To prevent intra-examiner variability, a highly trained oral and maxillofacial radiologist analyzed the visibility and volume of the pterygopalatine fossa twice at two-week intervals.

Statistical methods: An unpaired t-test or independent T-test is applied to verify the level of significant difference between males (right and left) and females (right and left) Pterygopalatine fossa volumes.

The Pearson Chi-square test was adopted to execute further analysis with respect to age and gender. P-values were considered significant if their value was less than 0.05. The data had been calculated using SPSS version 28.

Results

Based on the eligibility criteria, 214 PPF were included in the data from 107 patients. 53 of them were female, while 54 of them were male. The patients' ages ranged from eighteen to seventy years. In men, the average capacity of the pterygopalatine fossa was 717± 66.7 cc on the right side and 661±61.6 cc on the left. On the right side, 580± 82.8 cc and on the left, 579± 83.5 cc were the mean volumes of PPF for females. (Figure 2) When the results were analysed using the independent T-test, a P value of less than 0.05 was obtained, indicating that there is a significant difference between the right and left volumes of males and females ($p <0.01$). For men, 871 cc is the highest volume, and 521 cc is the lowest. For females, 320 cc is the lowest volume recorded, and 738 cc is the highest. (Figure 3)

The mean volume in the age group 18-30 years was found to be 571±92.7 cc on the right side and 574±90.91 cc on the left side in females; males had a mean volume of 681±55.05 cc on the right side and 629±62.02 cc on the left side. The highest volume noted in females was 717 cc, and 320 cc was the lowest volume recorded. In males, the highest volume was 757 cc and the lowest was 521 cc in this age group.

The mean volume in the age group 31-50 years was 659±109.8 cc on the right side and 595±93.08 cc on the left side in females, 690±61.4 cc on the right side, and 658 ± 53.2 cc on the left side in males. The highest noted volume in females was 738 cc, and 328 cc was the least measured volume. In males, 818 cc was the highest, and 568 cc was the least in this age group.

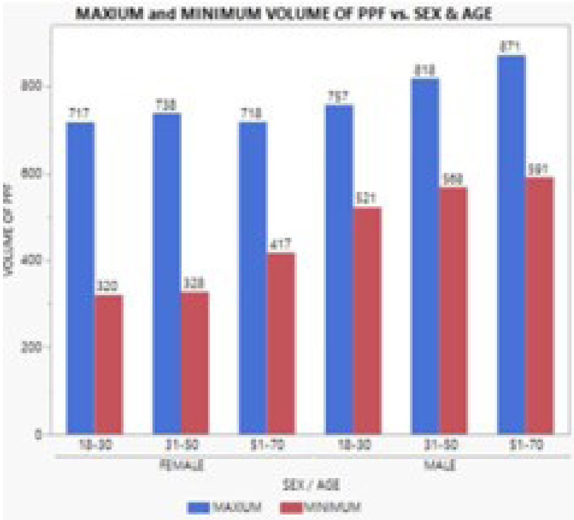

Figure 2: Mean Volume of Right and Left Pterygopalatine Fossa between Male and Females

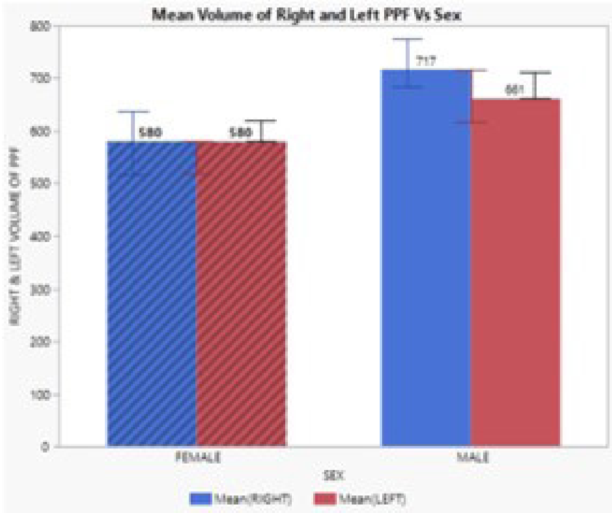

Figure 3: Maximum and minimum volume of pterygopalatine fossa among age groups and sex

In the age group above 51 years, females had a mean volume of 571 ± 72.21 cc on the right side and 585 ± 76.85 cc on the left side. Males had a mean volume of 757 ± 55.02 cc on the right side and 690 ± 61.24 cc on the left side. Females showed 718 cc of the highest volume, and 417 cc was the lowest. In males, 871 cc was the highest, and 591 cc was the least observed volume in this age group. (Figure 4)

Discussion

On the lateral side of the skull, below the orbit's highest point, is a little pyramidal region known as the pterygopalatine fossa (PPF). Pterygopalatine Fossa (PPF) is a fissure with an "inverse pyramid" pattern. It is attainable to break down the intricate pterygopalatine fossa boundaries into four walls and a roof. The anterior wall of the maxillary bone is formed by the posterior part, which also includes the alveolar process, infraorbital canal, and maxillary tuberosity (5). The maxillary sinus' posterior aspect is part of the anterior wall, reinforced by the sphenoid bone's pterygoid process. The lateral wall is invoked by the sphenoid bone's greater wing and maxilla's infratemporal surface. The medial wall consists of the palatine bone's perpendicular plate (6).

The vicinity, which is comparable to an inverted pyramid, is delineated by the convergence of the sphenoid, palatine, and maxilla bones. The 3D printed model of the PPF by Bannon et al. exemplifies that the PPF's factual shape is far more complex than a straightforward inverted pyramid (7).

In addition to dental treatments, cluster headaches and trigeminal neuralgia have been successfully controlled using local anesthetic injections into the pterygopalatine fossa. These diseases cause excruciating facial pain, which can be relieved by instilling a local anaesthetic into the pterygopalatine fossa, which interferes with the pain signals emanating from the involved nerves (8). Based on a prospective case series, it has been demonstrated that patients with trigeminal neuralgia or atypical facial pain can experience both short-term and long-term pain relief from ultrasound-guided injections of local anaesthetics and steroids into the pterygopalatine fossa. Fifteen patients who had not responded to prior medical or surgical interventions were included in the study (9).

There are two methods for administering the medication: through the Greater Palatine Fossa (GPF) and the sphenopalatine foramen. The less reliable method involves direct infiltration into the sphenopalatine foramen area. To effectuate this, a needle is inserted slightly beneath the back of the middle turbinates. The sphenopalatine foramen is typically difficult to identify; hence, the injection is generally given in the foramen's broad area. There could be a lack of vasoconstriction compared to that gained by delivering into the PPF through the GPF (10).

The more dependable method for efficacious and im-

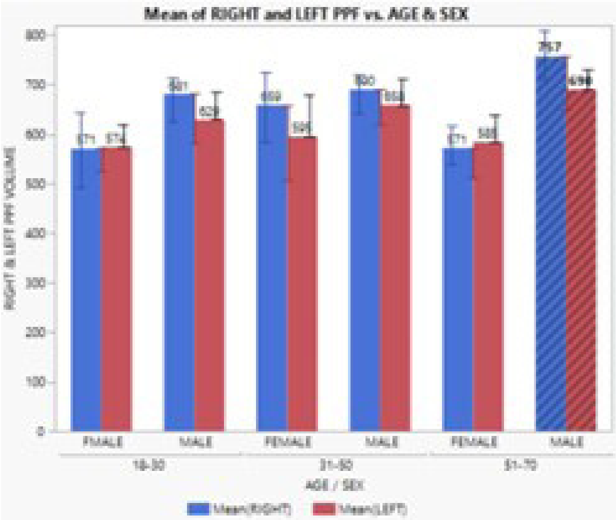

Figure 4: Mean volume of pterygopalatine fossa among different age groups and sex

pactful anesthetic delivery is injection into the PPF via the GPF. Essentially, a needle must be introduced into the GPF and passed through the PPF and Greater Palatine Canal (GPC) in order to do this treatment. The GPF is positioned precisely anterior to the posterior edge of the hard palate, crosswise from the upper molar teeth, when the palate is felt with the finger. Local anesthesia is injected into the PPF after the needle has been placed via the GPF. However, consequences from the GPF injection might include acute ophthalmoplegia, intracranial injection, infraorbital nerve damage, and intravascular injection (11).

Excessive local anesthetic volume in the pterygopalatine fossa can cause potential complications, including facial nerve paralysis or weakness, intravascular injection, orbital/ocular nerve damage, diplopia, strabismus, inadequate anesthesia, ptosis, positive blood aspiration, or trauma to the palatine nerves (12). Hematomas can form due to bleeding in the pterygopalatine fossa, triggered by excess local anesthesia. This can cause swelling, pressure, and pain and require additional treatment, especially if the injection site is not sterilized (13).

L. Stojcˇev Stajcˇic´, B et al. studied 85 dried human Caucasian skulls. Measuring the volume of the impression material inserted to fill the pterygopalatine fossa allowed for its determination. He reported that the median volume of PPF was estimated at 0.7 cm^3, with variations between 0.1 and 1 cm^3 (14). Wherein our study showed a similar mean volume of PPF around 717±66.7 cc on the right side, 661±61.6 cc in males of all age groups, the mean volume of females were slightly lesser, 580±82.8 on the right side to 579±83.5 on the left side.

Hwang et al. reviewed PPF in patients who had undergone diagnostic high-resolution CT (HRCT) scans (15). The mean volume of the PPF in males and females combined was 1039.96±280.0 mm3, which is significantly higher compared to females (580 cc) and males (690 cc) in our study.

A hundred patients with mean ages ranging from 18 to 85 years (mean 42.3±15.7 years for men and 49.3±21.7 years for women) who had previously had a maxillofacial CT scan were chosen by Daniele Gibelli et al. PPF volume was found to be 0.930±0.181 cm3 in males and 0.817±0.157 cm3 in females, with sex-related differences being statistically significant (p0.05) (16). Our present report shows the mean volume of PPF on the right side is 717±66.7cc and on the left side, 661±61.6cc in males. which is slightly on the lesser side, females showed a volume of 580±82.8cc on the right side and 579±83.5cc on the left side.

A study by Icen et al. examined CBCT data from 825 patients aged 18-91. Results showed significantly greater PPF volumes on the right side and in male patients. The study found lower volumes of PPF in patients aged 18-30, but less divergence in right and left side volumes. Icen et al. showed a significant rise in PPF volumes as patients aged, but the difference in right and left side volumes was smaller (17).

The variation in PPF volume can be attributed to the segmentation of PPF by various software programs. PPF volume varies based on ethnic, racial, or genetic variations among the Caucasian and Asian populations. The PPF volume may be influenced by different factors, resulting in variations in the anthropometric facial index (18–20).

Conclusion

An accurate appraisal of the volumetric capacity of the PPF is a prerequisite for the clinical application of a local anesthetic to the intricate and eclectic structure of the PPF. The volume of PPF in males was significantly greater than that in females. Semiautomatic CBCT picture segmentation gives researchers a practical, easily attainable, and independently tested method for these volumetric investigations. Furthermore, consideration should be devoted to the patient's side, gender, and age. With regard to our knowledge, our research is a sole attempt to report a volumetric characterization of the PPF using CBCT image segmentation. Therefore, additional research is needed to validate our conclusions. **R**

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References

1. Tashi S, Purohit BS, Becker M, Mundada P. The pterygopalatine fossa: imaging anatomy, communications, and pathology revisited. *Insights into imaging*. 2016;7(4): 589–599.
2. Wormald PJ, Athanasiadis T, Rees G, Robinson S. An evaluation of effect of pterygopalatine fossa injection with local anesthetic and adrenalin in the control of nasal bleeding during endoscopic sinus surgery. *American journal of rhinology*. 2005;19(3): 288–292.
3. Roberti F, Boari N, Mortini P, Caputy AJ. The pterygopalatine fossa: an anatomic report. *The Journal of craniofacial surgery*. 2007;18(3): 586–590.
4. Bahşi İ, Orhan M, Kervancıoğlu P, Yalçın ED. Morphometric evaluation and clinical implications of the greater palatine foramen, greater palatine canal and pterygopalatine fossa on CBCT images and review of literature. *Surgical and radiologic anatomy: SRA*. 2019;41(5): 551–567.
5. Salgado-Parente A, González-Huete A, Antolinos-Macho E, Michael-Fernández A, Quintana-Pérez JV, Alba-Pérez B, et al. Radiologist's Guide to the Pterygopalatine Fossa. *Radiographics: a review publication of the Radiological Society of North America, Inc*. 2023;43(11): e230078.
6. Behairy EA, Barsem NG, Eldemerdash AA. Evaluation of surgical approaches to infratemporal and pterygopalatine fossae. *The Egyptian Journal of Otolaryngology*. 2023;39(1): 109.
7. Bannon R, Parihar S, Skarparis Y, Varsou O, Cezayirli E. 3D printing the pterygopalatine fossa: a negative space model of a complex structure. *Surgical and radiologic anatomy: SRA*. 2018;40(2): 185–191.
8. Yin J, Wu Y, Zhang Z, Zhang Y, He J, Yang Z, et al. Operative management of trigeminal schwannomas: based on a modified classification in a study of 93 cases. *Acta neurochirurgica*. 2023;165(12): 4157–4168.
9. Nader A, Kendall MC, De Oliveria GS, Chen JQ, Vanderby B, Rosenow JM, et al. Ultrasound-guided trigeminal nerve block via the pterygopalatine fossa: an effective treatment for trigeminal neuralgia and atypical facial pain. *Pain physician*. 2013;16(5): E537–E545.
10. Aoun G, Nasseh I, Sokhn S. Radio-anatomical Study of the Greater Palatine Canal and the Pterygopalatine Fossa in a Lebanese Population: A Consideration for Maxillary Nerve Block. *Journal of clinical imaging science*. 2016;6: 35.
11. Hafeez NS, Ganapathy S, Sondekoppam R, Johnson M, Merrifield P, Galil KA. ANATOMICAL VARIATIONS OF THE GREATER PALATINE NERVE IN THE GREATER PALATINE CANAL. *Journal* . 2015;81: f14.
12. Brand HS, Bekker W, Baart JA. Complications of local anaesthesia. An observational study. *International journal of dental hygiene*. 2009;7(4): 270–272.
13. Cummings DR, Yamashita DDR, McAndrews JP. Complications of local anesthesia used in oral and maxillofacial surgery. *Oral and maxillofacial surgery clinics of North America*. 2011;23(3): 369–377.
14. Stojčev Stajčić L, Gačić B, Popović N, Stajčić Z. Anatomical study of the pterygopalatine fossa pertinent to the maxillary nerve block at the foramen rotundum. *International journal of oral and maxillofacial surgery*. 2010;39(5): 493–496.
15. Hwang SH, Seo JH, Joo YH, Kim BG, Cho JH, Kang

JM. An anatomic study using three-dimensional reconstruction for pterygopalatine fossa infiltration via the greater palatine canal. *Clinical anatomy* . 2011;24(5): 576–582.
16. Gibelli D, Cellina M, Cappella A. Disclosing the 'hidden' anatomical structures of the cranium: morphological and metrical assessment of pterygopalatine fossa and intrapetrous internal carotid artery .... *Italian Journal of*. 2018; https://oajournals.fupress.net/index.php/ijae/article/view/11410
17. Icen M, Orhan K. Cone-beam computed tomography evaluation of the pterygomaxillary fissure and pterygopalatine fossa using 3D rendering programs. *Surgical and radiologic anatomy: SRA*. 2019;41(5): 513–522.
18. Gallardo CAC, Galdames ICS, López MGC, Matamala DAZ, Coronado G, Suazo G, et al. Relationship between pterygopalatine fossa volume and cephalic and upper facial indexes. *International journal of morphology = Revista internacional de morfologia*. 2008;26(2): 393–396.
19. Vinod P. *Compare the effectiveness of normal saline to adrenaline (1:100000) in reducing intra operative bleeding following pterygopalatine fossa infiltration prior to performing endoscopic sinus surgery*. [masters] Christian Medical College, Vellore; 2015. http://repository-tnmgrmu.ac.in/9730/ [Accessed 7th November 2023].
20. du Plessis M, Navsa N, Bosman MC. Preliminary results on a study to locate the pterygopalatine fossa using mathematical formulae. *Clinical anatomy* . 2010;23(8): 931–935.

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