e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2023; 15(8); 1265-1271

Original Research Article

Anatomy of the Greater Palatine Foramen and Canal and their Clinical Significance in Relation to the Greater Palatine Artery

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Received: 08-06-2023 / Revised: 05-07-2023 / Accepted: 05-08-2023
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Conflict of interest: Nil

Abstract:

Introduction: The purpose of this research was to pinpoint the “greater palatine foramen (GPF)” in India with respect to other maxillary anatomical landmarks. Textbooks often identify the GPF as being between certain teeth or positioned opposite the last molar. The goal of this study was to offer a more precise location for GPF in the maxilla.

Aim and objectives: This study investigates the greater palatine foramen's anatomy and clinical significance to the artery.

Method: The objective of this study was to examine the spatial location of the greater palatine foramen in relation to specific anatomical features in both male and female skulls. A study was conducted on a sample of 100 adult skulls from Gujarat, India, comprising 59 males, 40 females, and 1 undetermined specimen. Distances between the foramen and significant landmarks were determined by employing Vernier callipers to get measurements. A quantitative assessment was conducted to evaluate morphological variances and gender-related differences.

Result: In male and female skulls, Table 1 shows the millimetre distances between the larger palatine foramen and the median palatine suture. In Table 2, the foramen's distances from the posterior hard palate are comparable. Table 3 categorises foramen locations in relation to maxillary molars and shows M3 prevalence in males (88.13%) and females (92.5%). The opening directions in Table 4 show a vertical orientation. Three women and three men participated in the study.

Conclusion: The larger palatine foramen was found near the third molar in 87.5% of skulls. This is relevant to trigeminal nerve block and anaesthesia.

Keywords: “greater palatine foramen (GPF)”, high tuberosity, trigeminal nerve block and anesthesia.

Introduction

The maxilla is made up of two palatal processes, and the palatine bones are on two horizontal plates that make up the hard palate, a key part of the skull that is connected by a vital suture created by the intersection of the four previously mentioned bones [1]. In maxillofacial surgery, it is usual practice to block the trigeminal nerve's maxillary division or one of its branches to provide local anaesthesia.

The hemimaxilla can be deeply sedated with the use of the maxillary nerve block. It is helpful for complex maxillary surgical treatments as well as quadrant dental procedures [2]. The upper and lower palatine canal can be accessed by the “greater palatine foramen (GPF)” or the high tuberosity, respectively, providing entry to the terminal location for anaesthetic administration. The GPF technique may be used to find the canal, and high tuberosity is associated with a higher frequency of hematoma main challenges with the usage of the corresponding approaches [3].

Dental implants placed inside the posterior maxilla to elevate the maxillary sinus may be performed as a common surgery in the private clinic if it were feasible to more accurately forecast and quickly anaesthetize utilising a single injection, the maxillary nerve and its branches [4]. This method is more well-liked by patients than one that calls for many injections. When using a common problem with a maxillary nerve block is the challenge of achieving deep anaesthesia, which is commonly brought on by the operator's failure to locate the GPF [5]. It is crucial to describe the GPF's location because of this. When necessary, the method for the maxillary nerve should be blocked using GPF taken into consideration with more comfort and confidence thanks to the necessary understanding and respect for the related anatomy. In the location known as the transverse the horizontal plates of the palatine bone merge with the palatine process located in the maxilla to form the palatine suture hard palate [6].

The “greater palatine artery (GPA)”, which rises out of The main source of blood supply for the mucosa that covers the hard palate is the descending palatine artery, which originates in the pterygopalatine fossa, travels via the “greater palatine canal (GPC)”, and develops into a “greater palatine foramen (GPF)” towards the posterior edge of the hard palate [7]. Despite the GPF can be found in a variety of places, it is often detectable by palpating the palate in front of the third maxillary molars. We came to the conclusion that the GPF may be more easily identified when several acute foramen, the middle of the maxillary suture, and both third maxillary molars are employed as anatomical reference points. the place where the GPA is verified and the arterial pulsations can be seen with adequate GPF identification [8].

The GPA runs anteriorly and is in close proximity to the alveolar ridge at the hard palate. Clinicians can utilise the perceptible crest that separates the larger palatine nerve from the artery, which it crosses, to localise both structures [9]. Its lateral branch from the GPA, whose main trunk enters the nasal cavity through the incisive foramen & unites the posterior septal branch for the sphenopalatine artery, supplies the anteroinferior area of the nasal septum.

The GPA's diameter is largest where it emerges from the GPF and progressively gets smaller as it moves in the direction of the incisive foramen. Most of the GPA's branches exit in the premolar region, frequently towards the alveolar side as opposed towards the hard palate [10]. To prevent the GPA's damage and the associated surgical and post-surgical difficulties, it is crucial to have a precise understanding of the GPA's position and size. It can be challenging to control bleeding from the GPA, and it has the potential to lead to considerable blood loss and necrosis of the palatal tissue. Damage of paresthesia is caused by the greater palatine nerve or inadequate anaesthesia for the ipsilateral hard palate, or damage caused by efforts to control bleeding, may result in postoperative pseudoaneurysms. In rare instances, temporary ophthalmoplegia may also occur [11].

The most frequent time for GPA injury is during the harvesting producing subepithelial connective tissue transplants, which can cause postoperative wound healing problems due to limited blood supply and extended intraoperative bleeding. The amount underlying subepithelial tissue connections grafts which are really governed by the position of the GPA & the amount that may be safely extracted from a hard palate degree of thickness underlying the palatal mucosa [12]. Additionally, GPA damage may be caused by down-fracturing the maxilla or with other surgical techniques such as pterygopalatine fossa infiltration, laser medial maxillectomy, and pterygomaxillary disjunction. In the process' culmination, a vasoconstrictor is either injected during endoscopic sinus surgery and septorhinoplasty, the larger palatine canal helps avoid hemostasis and restrict posterior epistaxis and an anaesthetic solution is injected into the pterygopalatine fossa to achieve hemi-maxillary anaesthesia throughout dental procedures through maxillary nerve block [13]. When choosing the appropriate By considering into account the anatomical characteristics in the mouth cavity while determining the location, angle, and length of the needle used for pterygopalatine fossa infiltration, doctors can optimise the efficacy and safety of these therapies. In addition, the endoscopic cauterization of the GPA at the incisive foramen to treat recurrent as well as uncontrolled anterior epistaxis, the radical release of the GPA during cleft palate repair as well as reconstruction, as well as the mobilisation for the GPA for closure of the oroantral fistula using mucoperiosteal pedicled palatal flaps are all clinically significant applications of the morphological parameters discussed [14].

Matsuda provided the initial account of where to find GPF. The foramen is typically simply described in broad terms in textbooks, such as opposing the last molar or medial to the last molar, or at the lateral palatal boundary or in the posterolateral border. Anaesthesia textbooks are a little bit more detailed when describing how the GPF is positioned in relation to the molar teeth. As a result, this is said to reside anywhere opposite the maxillary third or second molar as well as in the space between the maxillary third & second molars. The current study aims to point out the location of Greater Palatine Foramen with respect to number of anatomical elements.

Method

Research design

The objective of the study was to ascertain the spatial orientation of the greater palatine foramen in relation to several anatomical landmarks in both male and female skulls. The study utilized a sample of 100 adult human skulls, obtained from Medical Colleges in Gujarat, India. The sample consisted of 59 male skulls, 40 female skulls, and 1 skull of uncertain sex. The criteria for determining sex were established by assessing factors such as head size and muscle marks. The distances between the larger palatine foramen and median palatine suture, posterior palatal edge, and maxillary molars were recorded using Vernier callipers. In addition to measuring longitudinal palatal grooves, tooth levels were also recorded. The mean values and standard deviations were computed for each measurement in the skulls of both male and female individuals. The objective of this study was to examine morphological variations and get quantitative measurements pertaining to the location of the greater palatine foramen relative to particular anatomical landmarks in skulls of varying genders.

Inclusion and exclusion criteria

Inclusion

1. Human skulls that were adult, sexed, and preserved were used in the study.
2. Skulls were collected from several Indian medical schools in the state of Gujarat.
3. Male and female skulls were assigned gender according to their physical characteristics.
4. Adult human skulls were the only ones used in the research.

Exclusion

1. Juvenile or under-18 skulls were excluded.
2. Missing or badly damaged skulls that could compromise measuring accuracy were removed.
3. Skulls of undetermined sex or features that prevented sex classification were excluded.
4. The study removed skulls with insufficient or inconsistent measurements that impeded analysis.

Statistical analysis: The study analyzed data using a Z-test. The importance was determined using confidence bounds. When Z was less than 1.96 and p was more than 0.05, the results were not significant. When Z was more than 1.96 and p was less than 0.05, the results were significant. If Z was larger than 2.56 and p was less than 0.01, the results were extremely significant. This study analyzed the differences in observations across two subgroups, n(1) and n(2), revealing skull measurement variability.

Ethical approval

The IRB approved the study, guaranteeing the safety of the participants, the confidentiality of the data, and the observance of all ethical guidelines.

Result

Table 1 displays the measurements of the distances (in millimetres) between the greater palatine foramen and the median palatine suture in the skulls of both male and female individuals.The dataset includes observations from both the right and left sides, in addition to an observation from a side that is not stated. The right and left mean distances of male skulls were found to have respective standard deviations (SD) of 0.109 and 0.111, respectively. The average size of a female skull was measured to be 15.8 millimetres on the right side and 16.2 millimetres on the left, with standard deviations of 0.107 and 0.109 millimetres on each side. When measured along the axis of interest, the distance between the two sides was, on average, 16.8 millimetres (right) and 16.9 millimetres (left). Take a look at the statistics for the standard deviation if you want to determine how distant your data points are from the overall average.

Table 1: The palatine foramen is farther from the palatine suture in both sexes (millimetres)

Value	Male skulls		Female skulls		Unknown	
	Right	Left	Right	Left	Right	Left
No. of observations	59	59	40	40	1	1
Mean distance (mm)	15.9	16.6	15.8	16.2	16.8	16.9
SD	0.109	0.111	0.107	0.109	-	-

Table 2 presents the measurements of larger palatine foramen distances (expressed in millimetres) from the posterior margin of the hard palate in male and female skulls. The table presents measurements for both the right and left sides, along with a single observation from an unidentified side.

The average distances for male skulls were found to be 15.9 mm (right) and 16.6 mm (left), with standard deviations (SD) of 0.109 and 0.111, respectively. The mean distances of female skulls were found to be 15.8 mm (right) and 16.2 mm (left), with standard deviation (SD) values of 0.107 and 0.109, respectively.

However, the standard deviation value is not provided for the unknown side. The standard deviation (SD) quantifies the dispersion of measurements relative to the mean values.

Table 2: Greater palatine foramen distance (mm) from hard palate posterior margin in males and females

Value	Male skulls		Female skulls		Unknown	
	Right	Left	Right	Left	Right	Left
No. of observations	59	59	40	40	1	1
Mean distance (mm)	15.9	16.6	15.8	16.2	16.8	16.9
SD	0.109	0.111	0.107	0.109	-	-

Table 3 shows the larger palatine foramen's positional differences relative to the maxillary molars in male and female skulls. For each gender and one unidentified event, the table classifies observations by tooth placement (M4, M3, M*, M2). In male skulls (n=59), M3 was most common (88.13%), followed by M4 (8.47%) and M* (3.38%). Third molars (M3) were the most common (92.5%) in female skulls (n=40). After that, 5% had fourth molars (M4) and 2.5% had indeterminate molars (M*). The M4 instance was unidentified. The table shows the distribution of larger palatine foramen sites relative to maxillary molars in numerous skull samples.

Table 3: Variations in greater palatine foramen position relative to maxillary molars

Teeth	Male skulls (59)				Female skulls (40)				Unknown (1)				Total	
	Right GPF		Left GPF		Right GPF		Left GPF		Right GPF		Left GPF			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Medial to 4th molar	5	8.47	3	5.08	2	5	3	7.5	-	-	-	-	8	4.0
Medial to 3rd molar	52	88.13	51	86.44	37	92.5	35	87.5	1	2.5	1	100	170	85
Between 2nd and 3rd molar	2	3.38	5	8.47	1	2.5	1	2.5	-	-	-	-	7	3.5
Medial to 2nd molar	-	-	-	-	-	-	1	2.5	-	-	-	-	1	0.5

The opening direction of the “greater palatine foramen (GPF)” into the palate is depicted in Table 4. The data is categorized based on direction (horizontal and vertical) for both the right and left sides, specifically in male and female skulls. This study observed a limited sample of male and female skulls, consisting of three individuals of each gender, which displayed a horizontal opening direction on both the right and left sides. The vertical opening direction was seen in the majority of cases, with no significant difference between genders (97 in both males and females). The presented table provides a summary of the prevailing trend in the orientation of the glenoid fossa plane (GPF), revealing a higher occurrence of vertical orientation as opposed to the very seldom horizontal orientation observed in both male and female cranial specimens.

Table 4: Male and female larger palatine foramen opening direction into the palate

Direction	Right		Left	
	n	%	n	%
Horizontal	3	3	3	3
Vertical	97	97	97	97

Discussion

When doing soft tissue surgery either dental implants, One of the most important anatomical structures for both connective tissue and free gingival grafts is the greater palatine artery (GPA). The approximate position of the GPA has been determined by several studies, but due to significant individual variability, it cannot be determined during surgery.

In order to assess the viability of employing real-time nonionizing ultrasonography in implant surgery, the authors used intraoral ultrasound to monitor the GPA's development. Real-time GPA tracking can be performed with an intraoral ultrasonography probe, which is anticipated to significantly lessen the chance of bleeding after surgery [16].

A study done previously aimed to describe the greater palatine artery's (GPA) topography, paying close attention to how deeply it penetrates the palatal masticatory mucosa (PMM), as well as doing a morphometric examination of the palatal vault with the goal to provide helpful data that might be applied to various types of periodontal plastic surgery. In its work, 43 hemisected hard palates from adult Korean cadavers were embalmed. The specimens were decalcified, and then sectioned, after which the morphometry within the palatal vault was examined. An image analysis system was used to measure six parameters following a standard calibration [17].

The maxillary second premolar had the biggest gaps in between the GPA as well as the intersection of the cementoenamel and gingival surfaces. As it moved anteriorly, the smallest vertical distance that separated the GPA and the PMM steadily shrank. In comparison to the low-vault group, more deeply than the high-vault group, the GPA was positioned. The second premolar area in particular should be recommended as the optimum donor location for premolar tissue transplantation. The area may produce tissue with a maximal size & thickness of 9.3 mm & 4.0 mm, respectively [18].

One of the major blood arteries feeding the nasal septum is the larger palatine artery (GPA). We have published a unique method for employing a GPA flap to rebuild the "nasal septal perforation (NSP)". The potential and restrictions of employing a GPA flap in a front NSP repair are investigated in this radiological investigation. We explain how we fix the anterior-most NSP.

The GPA flap's radiological measures and its limitations were examined. Four patients who had NSP repair with a GPA flap were also included in the group [19]. An effective method for reconstructing anterior-most holes that are challenging to repair with conventional endonasal methods is the unilaterally GPA-pedicled flap. In this work, we used anatomical markers that are clinically recognisable to map the population in South-Eastern Asia's larger palatine foramen (GPF) topography Europe.25 of the 100 dry mature human skulls we used were somewhat edentulous, whereas 75 had bilateral dentations. A detailed understanding of GPF's numerous locations can help professionals offer better surgical methods in the region [20].

The goal of the work done previously aimed to provide a thorough macroscopic mapping of the palatal as well as tuberal blood supply utilising anatomical methods and analyse specific anastomoses in order to bridge the gap among fundamental structural and empirical clinical understanding. Combining several staining techniques has revealed information on the palatal blood supply, providing an effective tool for arranging for and carrying out of surgical treatments affecting the hard palate [21].

In order to reconstruct the orofacial region of an oncology patient, collect increased palatine nerve block and palatal donor tissue anaesthesia, it is important to investigate the computerised Location of the smaller palatine foramen (LPF) and larger palatine foramen (GPF) in three dimensions. The objective of the current work is to locate a patient-friendly landmark to standardise important anatomical features of a secure neurovascular bundle as well as designate the specific position of the GPF [22].

The research allowed for the investigation of the larger palatine neurovascular bundle's viability and variability as well as the use of specific software to compute the lengths of various parameters. Each space between the AR-GPF-PPB was equivalent to 4 mm in order to gather donor tissue for the neurovascular larger palatine network. Between the third & second molars, a 4 cm-long incision was made to access the IF measurement to determine the potential length of the transplant. The information we gathered for this study has been provided to enable surgeons to perform palatal treatments such as dentofacial orthopaedic surgery, palatal micro-implants, and posttraumatic dental repair without unexpected haemorrhage [23].

In order to cure a cleft palate, appropriate anatomy and physiology must be restored. The senior author has developed a novel method for the palatal cleft closure is facilitated by the dramatic release of the bigger palatine vessels without tension. Additionally, the palatal muscles are released and transposed by the use of an operating microscope, improving palate function. This method may be used on patients of all ages and is effective for treating all kinds of palate clefts. The effectiveness of cleft palate repair can be significantly enhanced by the radical release of the larger palatine artery as well as the levator complex transposition. This method is useful for the dynamic restoration of cleft palates and works well for all age groups [24].

To discuss the anatomy of the incisive foramen of the larger palatine artery, its transnasal endoscopic approach, and the significance of recurring front epistaxis as a result of the bigger palatine artery. It is safe and efficient to endoscopically cauterise the larger palatine artery within the incisive foramen to treat anterior epistaxis that recurs. The incisive foramen could function as expected, located a centimetre from the front nasal spine. Our case study data supports the aforementioned [25].

Conclusion

The study has concluded that the greater palatine foramen was discovered in close proximity to the maxillary third molar in a considerable majority of the skulls that were investigated, specifically 87.5% of them. This is the conclusion that can be drawn from the data of the study. Clinical significance is attached to the precise localization of this particular foramen, which must take into account both its proximity to the median palatine suture and the posterior margin of the palatal region. It is of particular value for therapies such as blocking the trigeminal second division or achieving posterior palatal anaesthesia. Both of these can be accomplished with this information. One potential constraint of this study is the utilization of desiccated craniums, which may not comprehensively depict the dynamic anatomical diversity observed in living organisms. Moreover, it is worth noting that the study's emphasis on a particular geographical area can neglect more comprehensive craniofacial factors.

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