

The relative position of the greater palatine foramen in dry Indian skulls

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ABSTRACT

Introduction: We evaluated the relative position of the greater palatine foramen (GPF) for precise injection of local anaesthetics, for optimal pain control in maxillofacial and dental surgeries.

Methods: The study was conducted in 132 adult dried unsexed skulls of the west coast region of Southern India. All the skulls studied were normal with fully erupted third molars and free from any pathological changes.

Results: The statistical analysis indicated there was no significant difference in the measurement between the right and left sides with regard to the distance of GPF to the midline, GPF to the incisive fossa, GPF to the posterior border of the hard palate. The angle made by the line joining the GPF to the incisive foramen with the palatal midline (GIM angle) on two sides showed statistical significance. The mean angle on the left side was 21.2 +/- 4.2 degrees and 20.1 +/- 4.2 degrees on the right side. In 74.6 percent of skulls, the GPF was located opposite the third maxillary molars, whereas 24.2 percent showed the GPF between the second and third molars. In 0.4 percent of skulls, the GPF was opposite to the second molar and in 0.8 percent of skulls, the GPF was situated beyond the third molar. 46.2 percent of the GPF was directed forward and medially, whereas 41.3 percent was directed forward, and 12.5 percent as directed forward and laterally.

Conclusion: The perpendicular distance of the GPF in Indian skulls was about 15 mm, the distance of GPF to incisive fossa was approximately 37 mm, and the GIM angle was 21 degrees.

Keywords: greater palatine foramen, hard palate, incisive foramen, skull anatomy

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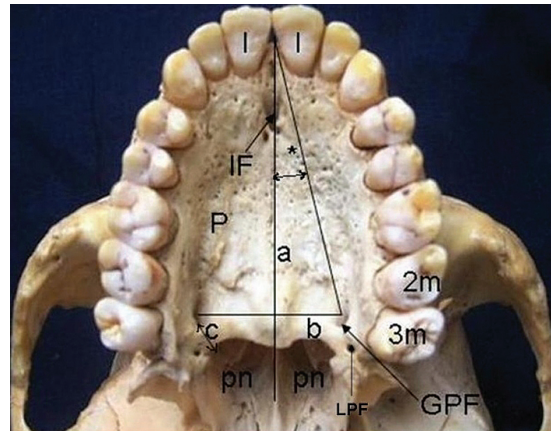


Fig. 1 Ventral photograph of the hard palate.

I: incisor teeth; IF: incisive foramen; GPF: greater palatine foramen; LPF: lesser palatine foramen; * Angle formed by the GPF with the midline; P: palatal vault; a: mid-sagittal line; b: line joining right and left GPF; c: distance between GPF and posterior border of hard palate; pn: posterior nasal aperture; 2m: second molar; 3m: third molar.

INTRODUCTION

The aim of the present study was to determine the relative distance, direction and angle made by the greater palatine foramen (GPF) with the palatal midline. Though the GPF is of great clinical significance, the published descriptions of the position of this foramen in the adult human skulls have not been consistent. Most of the textbooks locate the foramen in a general way, e.g. near the lateral palatal border,⁽¹⁾ in the posterolateral border,⁽²⁾ medial to last molar⁽³⁾ or opposite to the last molar.⁽⁴⁾ The position of the GPF in relation to the maxillary molars is stated to be opposite the second molar,⁽⁵⁾ opposite to the third molar or anywhere between the second and third molars.⁽⁶⁾ The first description of the location of GPF was reported by Matsuda.⁽⁷⁾ The GPF was found to lie 15 mm from the palatal midline and 1.9 mm anterior to the posterior border of the hard palate in East Indians.⁽⁸⁾ In Negroid skulls, the location of the foramen was 10–16 mm anteromedial to the pterygoid hamulus and was usually distal to the third maxillary molar on its midpalatal aspect.⁽⁹⁾ In a study on Kenyan skulls, 76% of cases showed the location of GPF opposite the third maxillary molar.⁽¹⁰⁾ In Chinese skulls, the GPF was commonly located between the second and third maxillary molars.⁽¹¹⁾ The foramen was located at a

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Table I. The distance of the GPF from the midline, the incisive fossa, posterior border of the hard palate, angle formed by the GPF with the midline and the number of lesser palatine foramina.

| Right & left sides n = 132 | Right | | Left | | Total | |
|---|-------|-------|------|-------|-------|-----------------------|
| | Mean | ± SD | Mean | ± SD | Mean | ± SD |
| GPF to midline (mm) | 14.7 | 0.155 | 14.7 | 0.146 | 14.7 | 0.261 p = 0.795 ns |
| GPF to incisive fossa (mm) | 37.2 | 0.292 | 37.4 | 0.301 | 37.3 | 0.731 p = 0.466 ns |
| GPF to posterior border of hard palate (mm) | 4.2 | 0.139 | 4.2 | 0.133 | 4.2 | 0.151 p = 0.88 ns |
| Angle between GPF and midline (°) | 21.1 | 4.2 | 21.2 | 4.2 | 21.1 | 2.0 p = 0.039 sig |
| Lesser palatine foramina | 1.8 | 0.802 | 1.9 | 0.887 | 1.8 | 0.655 p = 0.513 ns |

SD: standard deviation; ns: not significant; sig: significant.

Table II. The relation of GPF to the maxillary molars.

| Relation to maxillary molars | Right side n (%) | Left side n (%) | Total n (%) |
|---------------------------------|---------------------|--------------------|----------------|
| Second molar | 1 (0.8) | 0 | 1 (0.4) |
| Between second and third molars | 33 (25) | 31 (23.5) | 64 (24.2) |
| Third molar | 97 (73.5) | 100 (75.8) | 197 (74.6) |
| Behind third molar | 1 (0.8) | 1 (0.8) | 2 (0.8) |
| Total | 132 (100) | 132 (100) | 264 (100) |

$\chi^2 = 1.108$; $p = 0.775$, ns

distance of 4.11 mm from the posterior border of the hard palate and 16 mm from the mid-sagittal plane.⁽¹²⁾ The location of the GPF from the posterior border of the hard palate in Indian skulls was 3.7 mm, and in Nigerian skulls 3.5 mm, and this is fairly consistent. The foramen was commonly located medial to the third maxillary molar.⁽¹³⁾

METHODS

The study was conducted in 132 adult, dried, unsexed Indian skulls from the west coastal area of southern India. All the skulls studied were normal and free of any pathological changes, with fully erupted third molars. Unambiguous and well-defined points were taken and the following observations were made (Fig. 1). All the distances were measured with vernier calipers to the nearest millimetre. Each skull was examined for the following:

- Shortest perpendicular distance of the GPF to the midline (Fig. 1, line b).
- Distance of the GPF from the incisive fossa.
- Distance of the GPF from the posterior border of hard palate (Fig 1, line c).
- Relation of the GPF to the maxillary molars.
- Direction of the opening of the GPF into the oral cavity.

- The angle made by the line joining the GPF to the incisive foramen with the palatal midline (GIM angle). The three points taken to calculate the angle are: (1) the incisive foramen; (2) the angle made by the palatal midline (mid-sagittal line passing through the incisive foramen) and the line joining the GPF to the incisive foramen; and (3) the GPF.

- Shape of the palatal vault.

- Number of lesser palatine foramina (LPF).

The findings were tabulated and statistically analysed using Student's *t*-test. Side differences were analysed by using the chi-square test.

RESULTS

The statistical analysis indicated there was no significant difference in the measurement between the right and left side with regard to the distance of GPF to the midline, GPF to the incisive fosse, and GPF to the posterior border of hard palate ($p < 0.01$) (Table I). The GIM angle was variable on the right and the left sides ($p < 0.05$) (Table I), the mean angle on the left side was $21.2 \pm 4.2^\circ$ and $20.1 \pm 4.2^\circ$ on the right side. The relationship of the GPF to the

Table III. The direction of GPF in the oral cavity.

| Direction of the foramen | Right side n (%) | Left side n (%) | Total n (%) |
|--------------------------|---------------------|--------------------|----------------|
| Forward | 54 (40.9) | 55 (41.7) | 109 (41.3) |
| Forward and lateral | 18 (13.6) | 15 (11.4) | 33 (12.5) |
| Forward and medial | 60 (45.5) | 62 (47) | 122 (46.2) |
| Total | 132 (100) | 132 (100) | 132 (100) |

$\chi^2 = 0.315$; $p = 0.854$

Table IV. Shape of the palatal vault.

| Shape of palate | Number of skulls (%) |
|-----------------|----------------------|
| Arched | 61 (46.2) |
| Flat | 49 (37.1) |
| High-arched | 22 (16.7) |
| Total | 132 (100) |

maxillary molars was variable. In 74.6% of skulls, the GPF was located opposite the third maxillary molars, whereas 24.2% showed the GPF between the second and third molars. In 0.4% of skulls, the GPF was located opposite to the second molars, and in 0.8% of skulls, the GPF were situated beyond the third molar (Table II). The numbers of LPF on both sides were not symmetrical, and varied from one to four. In two skulls, the LPF on the left side were absent and in one skull, the GPF on the left side was double. 46.2% of GPF was directed forward and medially on the lateral border of the hard palate, whereas 41.3% was directed forward, and 12.5% of GPF was directed forward and laterally (Table III). Most of the palates were arched (46.2%, $n = 61$), whereas 37.1% ($n = 49$) were flat and 16.7% ($n = 22$) were high-arched palates (Table IV).

DISCUSSION

The present study indicated that the location of the GPF was more variable than is implied in the anatomy textbooks. Ajmani observed the location of the GPF opposite the third maxillary molar in 64% of adult Indian skulls,⁽¹²⁾ in comparison to our study which was seen in 74.6% of the skulls. Our study also showed the location of the GPF was opposite to the second maxillary molar in only 0.4% of the skulls, beyond the third maxillary molar in 0.8%, and between the second and third maxillary molars in 24.2% of skulls. The distance of the GPF from the midline was 14.7 mm on both sides in our study and almost equal to the data given by

Ajmani, i.e., 14.7 mm on right side and 14.6 mm on the left side.⁽¹²⁾ The GPF was 16.2 ± 1.3 mm lateral to the median saggital plane in the Thai skulls.⁽¹⁴⁾ The distance from the GPF to the incisive fosse was 37.3 mm on the left side and 37.2 mm on the right side in our study.

The distance of the GPF from the posterior border of hard palate on both sides was fairly constant, at a mean of 4.2 mm; Westmoreland and Blanton found a mean distance of 0.19 cm, from the posterior border of hard palate.⁽⁸⁾ Methathrathip et al reported the GPF 2.1 ± 1.3 mm anterior to the posterior border of the hard palate in Thais.⁽¹⁴⁾ Ajmani found this distance to be 3.7 mm in Indian skulls.⁽¹²⁾ The sutural growth occurring between the palatine bone and maxilla may be one of the reasons for the increase in anteroposterior dimension of the palate with the eruption of the posterior teeth.⁽¹⁵⁾

The GIM angle was unequal on the two sides, being more on the left side (Table I). This finding is of interest as it can reduce the attempts needed to introduce the local anaesthetic agents in maxillofacial surgeries or for dental procedures. This technique is also effectively useful in sinus and endodontic procedures, maxillary trauma, diagnosis and treatment of chronic oral and maxillofacial pain syndromes.⁽¹⁴⁾ The direction of GPF in the oral cavity was forward and medially in 46.2% and forward in 41.3%, as compared to 91.4% of Indian skulls.⁽¹²⁾ In 82% of skulls, the GPF was directed forward.⁽⁸⁾ The opening of the foramen was directed anterolaterally in a large number of Nigerian skulls (38.7%).⁽¹²⁾ This explains the variability of the GPF in different races and different geographical regions. This observation may explain the occasional difficulty encountered during surgery when attempting to insert the point of needle into the GPF.⁽¹²⁾

The majority of the skulls in the present study (46.2%) showed arched palatal vaults. 37.1% were flat palates and 16.7% showed very highly-arched palatal vaults. The palatal growth takes place in length in the sagittal plane anterior to the GPF.⁽¹⁶⁾ Bilateral symmetry in the number of LPF was seen in 40% of skulls. In two

skulls (1.51%), the LPF was absent on the left side. The present study gives an insight into the relative position of the GPF. However, more skulls of different races and geographical distribution should be studied to give a more conclusive finding. The variable GIM angle on two sides may indicate the near accuracy of the location of GPF and also the angle to be made by the needle for injecting local anaesthetics for optimal pain control in maxillofacial and dental surgeries in patients where general anaesthesia is contraindicated. In conclusion, this study shows that the perpendicular distance of GPF in Indian skulls was about 15 mm, the distance of GPF to the incisive fossa was approximately 37 mm, and the GIM angle was 21 degrees. These data will be helpful in comparing the Indian skulls with those from various other regions as well as comparing skulls of different races.

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