

Morphometric Assessment of the Greater Palatine Foramen with the Adjacent Anatomical Landmarks

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Abstract

Introduction: Blocking of the maxillary branch of the trigeminal nerve and its branches is a widely practiced procedure in numerous surgeries of the region such as dental implants in the posterior maxilla, maxillary sinus elevation and surgery in the maxillary quadrant, periodontal procedures, tooth extraction and abscess drainage. The route most commonly utilized in the oral cavity is through the Greater Palatine Foramen (GPF). GPF leads to the palatine canal which gives passage to the greater palatine nerve and vessels. The various published descriptions of the positional geometry of the GPF in the skull are in a much generalized manner without scarce information on the minor details. **Methods:** The present study was undertaken to define the exact position of GPF in relation to the well defined anatomical landmarks in the maxilla of Indian skulls. We studied 98 adult dried, unsexed human skulls. The measurements were taken with the help of stainless steel pointed caliper, scale in millimeters and a needle to show the direction of opening of the GPF. **Results:** The GPF was located opposite the maxillary third molar tooth in 72.44% of skulls. The direction of opening was forward and medially in 69.4%. The distance of the centre of the GPF to the posterior border of the hard palate was 14 mm on right and left side. **Conclusion:** These measurements shall assist the clinicians and interventionists to localize the GPF with far greater accuracy. These findings accrue interest as they can reduce the attempts needed to introduce local anaesthetic agents in surgeries involving the maxillofacial region as well as other dental procedures.

Keywords: reater palatine foramen; Incisive foramen; Hard palate; Maxillary molar teeth.

Introduction

The hard palate is an essential region of the skull formed by two palatal processes of the maxilla and two horizontal plates of the palatine bones. These bones are interlinked by a cruciform suture. Greater palatine foramen (GPF) is the foramen in the postero-lateral border of the hard palate through which the greater palatine nerves and vessels

pass to supply most of the palatal region. Greater palatine nerve is the branch of maxillary nerve which contains sensory and secretomotor fibers to nasal, palatine and pharyngeal glands. Greater palatine nerve descends through the greater palatine canal, emerges on the hard palate from the GPF, then it traverses forward in a groove on the inferior surface of the bony palate almost to the incisor teeth and supplies the gums and the mucosa and glands of the hard palate.

The greater palatine nerve block is widely used and is an effective method of attaining anesthesia of the hemi maxilla in various surgical modalities. The published analyses of the geometrical position of this foramen in the human skulls have not been very consistent and even the standard anatomy textbooks describe the foramen only in a much generalized way e.g. near the lateral palatal border[1], medial to the last molar tooth.[2] The present study was undertaken to define the

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(Received on 20.07.2013, accepted on 12.08.2013)

accurate position of the GPF relative to anatomical landmarks in the maxilla of Indian skulls.

Material and Methods

The present study was conducted on 98 normal human adult, dried, unsexed skulls available in the departmental collection of the participating institutes. All the skulls studied were free of any pathological changes. Well defined and unequivocal points were identified for the measurements. The measurements were taken with the help of pointed stainless steel sliding caliper, scale in mm and a needle to show the direction of opening of the GPF. All measurements were done bilaterally and directly on the dry skull. Each skull was examined for the following:

- a) The location of the GPF in relation to the maxillary molar tooth,
- b) Distance from the medial wall of the GPF to the midline maxillary suture (MMS),
- c) Distance of the posterior wall of GPF to the posterior border of hard palate,
- d) Direction of opening of the GPF on to the hard palate,
- e) Distance from the anterior border of GPF to the incisive foramen (IF),
- f) The angle between the MMS and the line passing from the incisive foramen to the GPF (GIM Angle).

Results and Discussion

The present study indicated that the location of the GPF in relation to the maxillary molars is variable, as reported by former authors. The location of GPF to the maxillary molars is shown in Table I.

In 72.44% the GPF was located opposite the third molar tooth, in 23.9% it was between the second and third molar teeth and in 3.06% the GPF was behind the third molar tooth. The distance of GPF to the mid maxillary suture

was variable from 12 mm to 18 mm (mean 14 mm) on both right and left side. The mean distance of GPF from the posterior border of hard palate was consistent bilaterally, at a mean distance of 3.4 mm. The mean distance from the anterior wall of GPF to the posterior border of incisive foramen was 28 mm and 32 mm on right and left side respectively.

The knowledge of direction of opening of the greater palatine canal on to the hard palate is essential to deliver the injections efficiently. We found the direction of opening was forward and medially in 69.4% followed by forward in 23.4% and forward and laterally in 7.2% of cases (Table II). The mean angle between the MMS and the line from the incisive foramen and the GPF (GIM angle) was 21.2° on the right side and 21.5° on the left side in 76% of the cases. In rest of the specimen, it was 22.9° on both the sides. A comparative analysis of the directions encountered by other workers is shown in Table III. These findings are of interest as it can reduce the attempts needed to introduce local anesthetic agent in the maxillofacial surgeries. A bony projection along the posterior margin of the GPF was observed in 28.3% of cases. It is formed by the raised posterior margin of the greater palatine foramen.

According to Saralaya and Nayak[3] the GPF was located medial to the maxillary third molar in 74.6% of cases, and Ajmani[4] found the GPF medial to third molar in 48% in Nigerian and 64% in Indian skulls. Slavkin *et al* reported that the GPF was located 1-3 mm distal to the maxillary third molar in adult skull.[5] Westmoreland and Blanton studied on three hundred skulls and reported that in 57% the GPF was located opposite or distal to the third molar tooth, the same in only in 6%, in 9.7% the GPF was medial to the second molar tooth.[6] The GPF was located opposite the third molar tooth in 76% of Kenyan skulls whereas in Chinese skulls it was commonly located between the second and third maxillary molar teeth. Chrcanovic R B *et al* studied on 80 Brazillian skulls and found that in 54.87% the GPFs were opposite to the maxillary third molar, 38.94 of foramina were

Table I: Variation in the location of GPF in relation to maxillary molars in Indian skull

| Relation to maxillary molars | Right side | Left side | Total | Percentage |
|---------------------------------|------------|-----------|-------|------------|
| Between second and third molars | 12 | 11 | 23 | 23.9 |
| Opposite the third molars | 35 | 36 | 71 | 72.44 |
| Posterior to third molars | 2 | 1 | 3 | 3.06 |

Table II: The direction of opening of GPF in the oral cavity

| Direction of the foramen | Right side | Left side | Total | Percentage |
|--------------------------|------------|-----------|-------|------------|
| Forward | 12 | 11 | 23 | 23.4 |
| Forward and medial | 34 | 34 | 68 | 69.4 |
| Forward and lateral | 3 | 4 | 7 | 7.2 |
| Total | 49 | 49 | 98 | 100 |

Table III: Comparison between studies in various geographical regions on the direction of opening of the foramen onto the palate

| Study | Nationality | Direction of opening of GPF | | | |
|--------------------------------------|-------------|-----------------------------|----------|----------------|----------|
| | | Antero medial | Anterior | Antero lateral | Vertical |
| Hasanali and Mwaniki (1984) | Kenyan | 76.0 | NA | NA | 24.0 |
| Wang <i>et al</i> (1988) | Chinese | NA | 90.5 | NA | 9.5 |
| Ajmani (1994) | Nigerian | 58.7 | NA | 38.7 | 3 |
| | Indian | 91.4 | NA | NA | NA |
| Saralaya and Nayak (2007) | Indian | 46.2 | 41.3 | 12.5 | NA |
| Chrcanovic BR and Custodio AL (2010) | Brazilian | 18.75 | 69.38 | 0 | 11.87 |
| Our study (2012) | Indian | 69.4 | 23.4 | 7.2 | 0 |

NA: Not Available

Table IV: Distance of GPF from Post border of hard palate

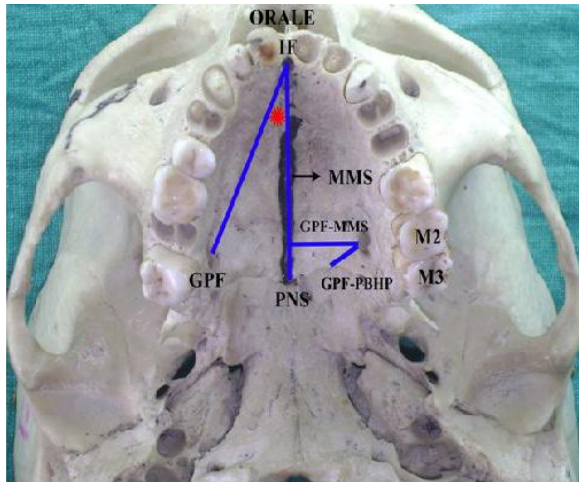
| Study | Nationality | Distance of GPF from Post border of hard palate (mm) |
|---------------------------------|------------------------|--|
| Methatharip (2005) | Thai | 2.1 |
| Wang <i>et al</i> (1988) | Chinese | 4.1 |
| Ajmani (1994) | Nigerian | 3.5 |
| | Indian | 3.7 |
| Saralaya and Nayak (2007) | Indian | 4.2 |
| Westmoreland and Blanton (1982) | American (East Indian) | 1.9 |
| Our study (2012) | Indian | 3.4 |

distal to third molar, and 6.19% between the second and third molars.[7] In the present study we found 72.44% of the GPF were located opposite the third molar tooth, in 23.9% between the second and third molar teeth and in 3.06% the GPF was behind the third molar tooth. These studies suggest that the position of GPF differs between ethnic groups. Furthermore it is very interesting to note that different studies from same country, India, reported data that differed among themselves in percentage of location of GPF in relation to the molar tooth, mean distance of GPF-PBHP and variation in the opening of the GPF onto hard palate. This suggests that large variation may also exist in the same

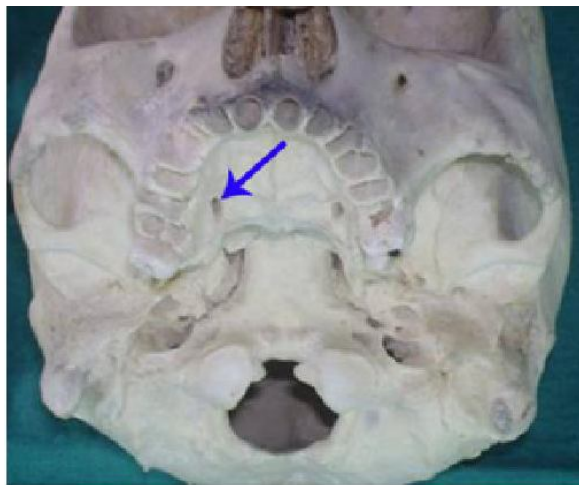
population. The variability in the position of GPF may be because of change in the position with relation to the development of the molars.

The distance of GPF from the posterior border of hard palate was consistent bilaterally, at a mean distance of 3.4mm. Ajmani reported this distance as 3.5 and 3.7 mm in Nigerian and Indian skulls respectively. [4] Westmoreland and Blanton[6] found a mean distance of 1.9 mm from PBHP, Wang *et al*[8] 4.11 mm and Methatharip *et al*[9] found the GPF 2.1± 1.3 mm anterior to the posterior border of hard palate. Saralaya and Nayak[3] observed a mean distance of 4.2 mm in 132 skulls.(Table IV). Variability in the

Photograph 1: Showing Hard palate, GPF (Greater Palatine Foramen), IF (Incisive Foramen), M2 (Maxillary Second molar tooth), M3 (Maxillary third molar tooth), MMS (Midline Maxillary Suture), GPF-PBHP (Distance between posterior wall of GPF to the posterior border of hard palate), GPF-MMS (Perpendicular distance from medial wall of GPF to the MMS), GIM Angle (The mean angle between the MMS and the line from the IF and the GPF (GIM angle-red asterisk))



Photograph 2: Showing the direction of opening onto the hard palate (antero-medially)-blue arrow



location of the foramen may be related to the sutural growth occurring between the maxilla and the palatine bones. The anteroposterior dimension of the palate increases with the eruption of the posterior teeth.

In order to administer injections, the

direction of the opening of the greater palatine canal should be kept in mind. Ajmani found that the opening of the foramen was directed in an anteromedial direction in 58.7% Nigerian and 91.4% Indian skulls.[4] In 38.7% of Nigerian skulls the direction of opening was anterolaterally pointing towards maxillary molars. Saralaya and Nayak reported it was forward and medially in 46.2% and forward in 41.3%. [3] In Brazilian skulls the direction of opening was anterior in 69.38% followed by anteromedial in 18.75% and vertical in 11.87%. In present study the direction was forward and medially in 67.3% followed by forward in 23% and forward and laterally in 9.78% of cases. These variations explain that the occasional difficulty encountered during insertion of the needle into GPF. If observed geographically, in Indian skulls the opening is directed anterior or anteromedially whereas in Chinese skull it is anterior or vertical and in Kenyan skulls the opening is anteromedial or vertical.

The distance from the MMS and PBHP to the GPF also showed variation in the literature. According to Westmoreland and Blanton, the distance GPF-MMS on the right had a mean of 14.8 mm and 15 mm on the left.[6] Ajmani mentioned a distance of 15.4 mm from the sagittal plane in Nigerian skulls and 14.7mm on the right and 14.6mm on the left in Indian skulls [4]. Saralaya and Nayak reported 14.7 mm on both sides [3]. Wang et al found it 16 mm.[8] Chrcanovic *et al* reported it as 14.68 mm on right and 14.44 on the left side.[7] We found this distance as 14.61 mm on the right and 14.7 mm on the left side.

A bony projection, formed by the raised posterior margin of the foramen was observed in 21% of cases. Ajmani[4] mentioned this bony projection in 24.6% whereas Westmoreland and Blanton[6] in 16% of skulls. This projection may be helpful in preventing the clinical hazards associated with the injection by obstructing the needle. The distance from the GPF to the incisive fossa was 37.3 mm on left side and 37.2 mm on the right side in the study of Saralaya and Nayak [3] which was similar to the findings of the

Chrcanovic *et al.*[7] We found this distance to be 28mm and 32 mm on right and left side respectively. The mean angle between the MMS and the line joining the incisive foramen to the GPF was almost equal on both the sides (right=22.12°; left= 23.3°). Saralaya and Nayak reported small difference between two sides (right= 21.1°; left=21.2°).[3] These data will be helpful in comparing the skulls with those of the skulls of different other regions as well as comparing the skulls of different races. It also provides the anatomical references to block the maxillary division of the trigeminal nerve through the GPF accurately to avoid the risk of haematoma resulting from the vein puncture of the pterygoid plexus.

Summary and Conclusion

The GPF was related opposite to the third molar tooth in 72.44% of cases which was consistent with Hasanali[10], Saralaya and Nayak.[3] The direction of opening of GPF to the palate is forward & medial in 69.4% of cases which is in accordance of Ajmani,[4] Chrcanovic[7] & Hasanali.[10] The GIM angle was 21.2 in 76% of cases. The present findings accrue an additional interest as these can assist the interventionists in reducing the attempts required to inject local anesthetics in the numerous manoeuvres involving the maxillofacial region as a whole and the dental procedures in particular.

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