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Osteometric Analysis of Palatal Spine in Dry Skulls with Dentate and Edentulous Superior Alveolar Arches in a Brazilian Sample

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ABSTRACT

Introduction: The palatal spine exists independently of the presence (or lack) of teeth, and the dentist can generally palpate it through the mucosa of the hard palate to assist in locating the greater palatine groove and its neurovascular bundle, as there are no morphometric data on this structure in a sample of the Brazilian population.

Method: 75 dry human skulls with dentate and edentulous upper alveolar arches were analyzed. The skulls, belonging to the Forensic Osteology Laboratory at the Federal University of Pernambuco (LAOF/UFPE), were from adult individuals, without distinction of sex and ethnicity. Variables were analyzed using the Shapiro-Wilk normality test and paired Student's t test or the Wilcoxon test (for continuous variables) or the chi-square test (for categorical variables). For all analyses, a significance level of 5% and a confidence interval of 95% were considered.

Results: The APLPS was of 11.05mm (+/-3.94) on the right side and 10.55mm (+/-3.23) on the left side. The LMLPS was of 1.73mm (+/-1.413) on the right side and 1.68mm (+/-1.44) on the left side. The GPF-PEPS was 10.94mm (+/-2.45) on the right side and 10.66 mm (+/-2.47) on the left side. The MPS-PS was of 12.05mm (+/-2.07) on the right side and 12.21mm (+/-2.04) on the left side. MPS-AEPS was of 10.99mm (+/-2.02) on the right side and 11.36mm (+/-2.17) on the left side; and IF-AEPS was of 19.04mm (+/-4.22) on the right and 19.52 (+/-4.21) on the left side. Only MPS-AEPS showed a statistically significant difference when the right and left sides were compared ($p<0.05$).

Conclusion: The palatine spine was more elongated in the anteroposterior direction and flatter in the latero-medial direction, with equivalent distances from its anterior and posterior ends to the median palatal suture and the greater palatine foramen, respectively. The difference observed in the MPS-AEPS statistical test showed that there was a small asymmetry between antimeres.

Keywords: Anatomy; Hard palate; Morphometry.

Introduction

The palate constitutes the upper wall of the oral cavity, where its two anterior thirds are formed by the hard palate (bone palate) and its posterior third is the soft palate, formed mainly by musculo-aponeurotic and glandular tissue[1]. The hard palate is made up of the palatine processes of the maxillae and the horizontal plates of the palatine bones and is characterized by the presence of foramina, sutures and bony prominences[2].

The mucosa of the hard palate is similar to the gingiva, as both are classified as masticatory mucosa, and has three histological layers: a keratinized epithelium, a dense lamina propria that is important for vascularization and resistance to functional stress, and a submucosa located deeply to the other layers[3,4]. The palate is considered the main donor area for removing subepithelial connective tissue grafts, used for various periodontal and peri-implant procedures[3].

The Greater Palatine Artery (GPA) is the main artery of the hard palate. It originates from the descending palatine artery in the pterygopalatine fossa and passes through the greater palatine canal to emerge through the greater palatine foramen on the lower surface of the hard palate[5]. The GPA runs in the lateral groove of the bony prominence and commonly divides into a lateral, a medial and a canine branch after passing through the palatal spine[6]. Although the region is widely used as an autogenous donor site for periodontal and peri-implant mucogingival surgery, it only provides a limited donor area, given the risk of injury to the GPA[7].

As this is an area that is difficult to visualize perioperatively, there is a need to seek knowledge of the anatomical landmarks of the hard palate, mainly in relation to reduce the potential risk of damaging the GPA and the entire greater palatine neurovascular bundle[7]. In order to reduce bleeding accidents that

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may occur during the collection of connective tissue grafts from the hard palate, solid knowledge of the anatomical bases of this region is important[8].

One of these landmarks is the palatal spine, a short bony prominence that exists regardless of the presence (or lack) of teeth, and the dentist can usually palpate it because it forms the margins of the greater palatine grooves on both sides[10,11]. Incomplete canals connected by a fibrous or ossified band may be formed along the greater palatine groove forming partial roofs. The presence of bone bridges and partial roofs of the greater palatine groove can cause problems when infiltrating the anesthetic solutions for local anesthesia of the greater palatine nerve, but which, however, can protect the GPA against scalpel blades during connective tissue graft harvesting[12].

Therefore, the aim of the present study was to analyze osteometric aspects of the palatal spine in dry human skulls with dentate and edentulous upper alveolar arches.

Materials and Method

Ethical Aspects and Sample Size Calculation

In accordance with Brazilian Federal Law 8,501, of November 30, 1992, only legally useful dry skulls were used for study purposes, with prior authorization from the Anatomy Department of the Federal University of Pernambuco (UFPE). Furthermore, the Research Ethics Committee approved an umbrella project of the Health Sciences Center of the Federal University of Pernambuco (CCS/UFPE), with Certificate of Presentation of Ethical Appreciation (CAAE) 30916420.5.0000.5208.

The sample, obtained through sample calculation, based on the hypothesis of 95% symmetry between contralateral structures of the hard palate, 95% confidence level and standard error of 5%, was of 75 dry human skulls stored in the Anthropology and Osteology Laboratory Forensics (LAOF) of the Anatomy Department of the Federal University of Pernambuco (UFPE).

Eligibility Criteria

Dry human skulls were included without distinction of sex, ancestry and height, but showing evidence that the upper third molars were already erupted, totally or partially, or even that they had already been extracted; they also had bone integrity of the studied structures of the hard palate and of the anatomical landmarks that served as a reference for carrying out the measurements. Skulls were excluded in which anatomical characteristics of individuals who were not yet adults were identified, such as: presence of fontanelles, deciduous or mixed dentition and spheno-occipital synchondrosis evident at the base of the skull.

Variables

The following variables were considered (Figure 1):

1) anteroposterior length of the palatal spine (APLPS);

2) lateromedial length of the palatal spine (LMLPS);

3) distance from the center of the greater palatine foramen to the posterior end of the palatine spine (GPF-PEPS);

4) distance from the center of the palatal spine to the median palatal suture (PS-MPS);

5) distance from the anterior end of the palatal spine to the median palatal suture (MPS-AEPS);

6) distance from the anterior end of the palatal spine to the posterior margin of the incisive foramen (IF-AEPS);

7) inclination of the long axis of the palatal spine;

8) morphology of the superior alveolar arch.

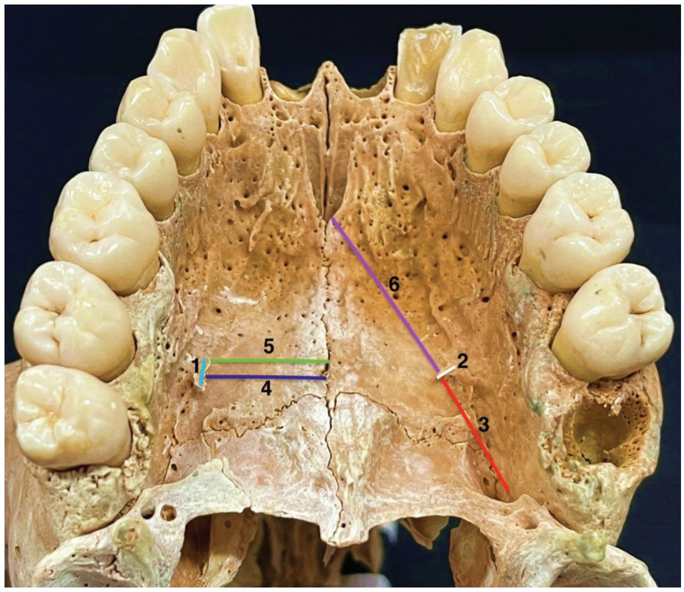

Figure 1. 1/light blue line = anteroposterior length of the palatal spine (APLPS); 2/white line - lateromedial length of the palatal spine (LMLPS); 3/red line = distance from the center of the greater palatine foramen to the posterior end of the palatine spine (GPF-PEPS); 4/dark blue line = distance from the center of the palatal spine to the median palatal suture (PS-MPS); 5/green line = distance from the anterior end of the palatal spine to the median palatal suture (MPS-AEPS); 6/pink line = distance from the anterior end of the palatal spine to the posterior margin of the incisive foramen (IF-AEPS).

Measures and Morphological Analysis

The measurements of continuous variables were carried out using a digital caliper (Titan, TIT-C454, 200mm) always by two previously calibrated evaluators. The morphology (shape) of the superior alveolar arch was classified as triangular, rectangular, parabolic, and ovoid through visual inspection. Also through visual inspection, the dental status of the upper alveolar arch was classified as dentate and edentulous, where the skull that presented bilateral posterior teeth was considered as dentate.

Statistical Analysis

For continuous variables, the Shapiro-Wilk normality test was used to determine data distribution. The paired Student's t test was used for normal data distribution and the Wilcoxon test for abnormal data distribution.

For categorical variables, that is, the inclination of the long axis of the palatal spine and the morphology of the superior alveolar arch, the chi-square test was used to make comparisons.

A calibration was performed with 30% of the sample before definitive measurements and inspections could be carried out. The level of agreement between evaluators was determined using the interclass correlation coefficient (for continuous variables). All data were initially allocated to specific collection forms for the present study. This research considered a significance level of 5% and a confidence level of 95%. All statistical analyzes were performed using GraphPad Prism 6.01 software (GraphPad, San Diego, California, United States).

Results

Calibration with 30% of the sample showed an agreement of 0.814 (81.4%) between evaluators using the interclass correlation coefficient, for continuous variables (confidence interval: 95%; lower limit: 0.586; upper limit: 0.917).

The average anteroposterior length of the palatal spine (APLPS) was 11.05 mm (+/- 3.94) on the right side and 10.55 mm (+/- 3.23) on the left side, observing a statistically non-significant value, after comparison ($p>0.05$).

The latero-medial length of the palatal spine (LMLPS) presented an average of 1.73 mm (+/- 1.413) on the right side and 1.68 mm (+/- 1.44) on the left side, not showing statistical significance ($p>0.05$).

The mean distance from the center of the greater palatine foramen to the posterior end of the palatal spine (GPF-PEPS) was 10.94 mm (+/- 2.45) for the right side and 10.66 mm (+/-2.47) to the left side. After comparison, it was not statistically significant ($p>0.05$).

The distance from the center of the palatal spine to the median palatal suture (MPS-PS) presented an average of 12.05 mm (+/- 2.07) for the right side and 12.21 mm (+/- 2.04) to the left side, not showing statistical significance ($p>0.05$).

The mean distance from the anterior end of the palatal spine to the median palatal suture (MPS-AEPS) was 10.99 mm (+/-2.02) for the right side and 11.36 mm (+/- 2.17) to the left side. After comparison, it presented statistical significance ($p<0.05$).

The distance from the anterior end of the palatal spine to the posterior margin of the incisive foramen (IF-AEPS) presented an average of 19.04 mm (+/- 4.22) for the right side and 19.52 mm (+/- 4.21) to the left side, not showing statistical significance ($p>0.05$).

Regarding categorical variables, the inclination of the long axis of the palatal spine showed, on the right side, an anterior and medial direction in 74 cases (98.66%) and was straight in in only 01 case (1,33%). On the left side, in all 75 cases (100%) the long axis of the palatal spine showed an anterior and medial direction.

The morphology of the superior alveolar arch was classified as open parabolic in 73 cases (97.33%) and as closed parabolic in 02 cases (2.66%).

Discussion

The present study analyzed 75 upper alveolar arches of dentate and edentulous adult individuals to determine the dimensions of the palatal spine and its distances from other important anatomical landmarks, in order to avoid injuries to the greater palatine neurovascular bundle.

The palatine process of the maxilla is a rough structure, which differs from the horizontal plate of the palatine bone. Anteriorly to the greater palatine foramen and posterolateraly to the incisive foramen, there are small prominences, the palatine spines, which circumscribe two or more palatine grooves, in an anteroposterior direction[1]. Laterally, medially or both medially and laterally to the palatal spine, lies the greater palatine groove, which is extremely important, as the greater palatine neurovascular bundle passes through it, for irrigation, drainage and innervation of the structures associated with the two posterior thirds of the hard palate[5].

As the palatine spine and greater palatine groove exist due to the greater palatine nerve and blood vessels, it is assumed that they exist independently of the presence (or lack) of teeth, and the dentist can usually palpate it under the mucosa of the hard palate[10,11]. It is described as a short, blunt and distinct bony prominence, which can connect to the alveolar process of the maxilla through fibrous bands, or even ossifications, which can form incomplete canals. The presence of incomplete bony or fibrous bridges from the palatal spine can difficult the greater palatine nerve block but can provide protection against the scalpel blade when harvesting soft tissue grafts from the hard palate[2].

When considering all skulls in the same analysis, regardless of dental situation, a statistical significance ($p<0.05$) occurred for MPS-AEPS variable, presenting a slight asymmetry on both sides, unlike other five variables (APLPS, LMLPS, GPF-PEPS, MPS-PS and IF-AEPS), which were symmetrical for both antimeres and dental situations. Table 1 summarizes these data, which may aid clinicians as it provides anatomical basis during the dimension planning phase in periodontal surgeries, such as in subepithelial connective tissue graft surgeries of the palate[5,13,14].

The palatine spine borders the greater palatine groove and has two ends, an anterior one, facing the anterior region of the hard palate, closer to the incisive foramen, and a posterior one, facing the posterior region of the hard palate and closer to the greater palatine foramen; Furthermore, it has a central region that connects these other two parts already mentioned[6]. In the present study, its long axis was tilted anteriorly and medially. Thus, its anterior end was closer to the median palatal suture and the incisive foramen, and its posterior end was closer to the alveolar process of the maxilla and the greater palatine foramen. This indicates that the greater palatine artery may be closer to the same region at this level, a place where it is larger, as Yu *et al* (2014) showed in their study, in which the greater palatine artery was commonly present in the most lateral groove, when compared to the course of the greater palatine nerve. These results can be seen in Table 2.

The shape of the superior alveolar arch can be classified as triangular, rectangular, parabolic and ovoid. In the present study, the parabolic shape was the most common. This is the form generally found in the adult population and is related to several factors, such as tooth quantity, intercondylar distance and ethnicity, for example[15].

Table 1. Continuous variables expressed as mean and standard deviation. *= indicates statistically significant value; mm = millimeters; APLPS = anteroposterior length of the palatal spine; LMLPS = lateromedial length of the palatal spine; GPF-PEPS = distance from the center of the greater palatine foramen to the posterior end of the palatine spine; MPS-PS = distance from the center of the palatal spine to the median palatal suture; MPS-AEPS = distance from the anterior end of the palatal spine to the median palatal suture; IF-AEPS = distance from the anterior end of the palatal spine to the posterior margin of the incisive foramen.

	Right Side	Left Side	p-value
APLPS	11,05 mm (+/-3,94)	10,55 mm (+/-3,23)	0.2286
LMLPS	1,73 mm (+/-1,413)	1,68 mm (+/-1,44)	0.2008
GPF-PEPS	10,94 mm (+/-2,45)	10,66 mm (+/-2,47)	0.1294
MPS-PS	12,05 mm (+/-2,07)	12,21 mm (+/-2,04)	0.4549
MPS-AEPS	10,99 mm (+/-2,02)	11,36 mm (+/-2,17)	0.0328*
IF-AEPS	19,04 mm (+/-4,22)	19,52 mm (+/-4,21)	0.2018

Table 2. Inclination of the long axis of the palatal spine on the hard palate.

Direction	Right Side (%)	Left Side (%)
Anteromedial	74 (98,66%)	75 (100%)
Straight	01 (1,33%)	0 (0%)

To the best of the authors knowledge, there are no similar studies with samples from the Brazilian population, such as the methodology of the present study. Therefore, literature on the subject, within Brazil, is scarce, and even outside the country there are few papers that have addressed this topic. Table 3 compares the results and methodology of the present work with others carried out on the topic.

Clinically, the presence of bony prominences along the grooves and at the opening of the greater palatine foramen may present problems in the administration of local anesthesia and in the construction of dental prostheses[12]. Such problems reported in the literature are generally found in structures in which it is not possible to perform digital palpation due to the thickened and loose mucosa in the posterior part of the hard palate. However, if palpable, they serve as a guide for the clinician[6,11,12].

The mucosa of the palate is usually used as a donor site for connective tissue and free gingival grafts in the treatment of periodontal and peri-implant conditions[13,14]. The existing risk of damaging the greater palatine artery, due to the difficulty encountered by clinicians in locating it, mainly due to the fact that it cannot be directly seen during the most common procedures, can lead to intraoperative problems, such as intense bleeding, in addition to the risk of necrosis and spread of infections[15]. Thus, the dentist who performs surgical procedures on the hard palate, with the proper knowledge of the morphology and morphometry of structures that serve as an anatomical landmarks for locating the greater palatine vascular-nervous bundle, can promote minimization of damage to these noble structures, which are important for maintaining irrigation, drainage and innervation of the palatal region[11-14].

Conclusions

The palatal spine was present in a statistically symmetrical way in the upper dental arches on both sides in terms of its anteroposterior and lateromedial length;

The distance from the greater palatine foramen and the median palatal suture to the posterior end and the center of the palatal spine, respectively, was also symmetrical for both sides and both dental situations;

The distance from the anterior end of the palatal spine to the median palatal suture showed a certain

Table 3. Comparison between present and previous studies regarding morphometry of palatal spine. Measures were reported in millimeters. APLPS = anteroposterior length of the palatal spine; GPF-PEPS = distance from the center of the greater palatine foramen to the posterior end of the palatine spine; RS: right side; LS: Left side; N: sample.

Study	Year	Population	N	Variables	
				APLPS	GPF-PEPS
Yu *et al.*	2014	Korean	25	10,42 ± 2,45	6,49 ± 1,76
Present study	2024	Brazilian	75	11,05 ± 3,94 (RS) 10,55 ± 3,23 (LS)	10,94 ± 2,45 (RS) 10,66 ± 2,47 (LS)

asymmetry for the right and left sides, regardless of the dental situation;

The distance from the anterior end of the palatal spine to the posterior margin of the incisive foramen was statistically symmetrical for the right and left sides, regardless of the dental situation;

The palatine spine was more elongated in the anteroposterior direction and flatter in the lateromedial direction, with equivalent distances from its anterior and posterior ends to the median palatal suture and the greater palatine foramen, respectively;

The morphology of the superior alveolar arch was classified as parabolic in most cases.

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Ethics Statement

The authors state that every effort has been made to follow all local and international ethical guidelines and laws that pertain to the use of human cadaveric donors in anatomical research (Iwanaga *et al.*, 2022).

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