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ANATOMICAL STUDY OF THE GREATER PALATINE ARTERY: CLINICAL IMPLICATIONS FOR PALATAL GRAFT PROCEDURES

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ABSTRACT

Background The palate is a well-established donor site for obtaining graft tissue, but it is limited by the proximity to the adjacent teeth and the greater palatal artery.

Methods A total of 10 cadaver hemifaces were dissected perpendicular to the median palatine raphe (MPR) from the greater palatine to the incisive foramen into vertical slices of 3 mm in width. On each slice, the distance from the epithelial surface to the superior border of the GPA, the diameter, the distance from the inferior border of the vessel to the bone, the distances from the MPR and from the teeth or midline of the alveolar crest to the GPA were measured.

Results The mean tissue thickness above the GPA was 4.30 mm ranging from 1.92 – 8.72 mm. It decreased from the 3rd molar to the canine area with the greatest thickness being in the 2nd molar region and the shallowest in the lateral incisor region. A significant correlation (R2 = 0.92) was found between the total palatal tissue thickness and tissue thickness above the GPA.

Conclusion The mean tissue thickness above the GPA was 4.30 mm ranging from 1.92 – 8.72 mm. It decreased from the 3rd molar to the canine area with the greatest thickness being in the 2nd molar region and the shallowest in the lateral incisor region. A significant correlation (R2 = 0.92) was found between the total palatal tissue thickness and tissue thickness above the GPA.

KEYWORDS

Connective Tissue Grafts; Dental Research; Free Gingival Grafts; Greater Palatine Artery; Periodontics.

1. INTRODUCTION

The palate is a well-established donor site for obtaining graft tissue in periodontal plastic surgical procedures [1,2] such as free gingival grafts (FGG) or connective tissue grafts (CTG). However, proximity to the adjacent teeth on the lateral aspect of the palate and the greater palatine neurovascular bundle (GPB) on the medial aspect limit the amount of graft tissue that can be obtained from the palate. Previous studies have been concerned with the location of the greater palatine foramen (GPF) as well as the greater palatine artery (GPA) and have established guidelines on how to estimate the distance between the teeth and the GPB. Reiser et al. (1996) determined in their cadaver study that the average distance between the cemento-enamel junction (CEJ) of the maxillary posterior teeth and the greater palatine neurovascular structures in an average palate is 12 mm, in a shallow palate is 7 mm and in a high palatal vault is 17 mm [3]. Comparable results were found by Benninger et al. (2012) who detected a range of 9 - 16 mm from the CEJ of the first molar to the coronal neurovascular structure [4] Traditionally, clinicians follow these guidelines and choose to avoid removing graft tissue in the area close to the GPB out of fear of possible complications such as hemorrhaging and paresthesias [5-9].

Like previous studies, [3,4] for all measurements in this study, human cadaver tissue was used. The question arises how closely cadaver tissue resembles living human tissue. Simpson and Henneberg (2002)

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investigated in their forensic study the effect of tissue embalming on facial soft tissue. Following death, there is considerable dehydration of tissues, sufficient to affect the application of the use of unembalmed cadavers when comparing it to the soft-tissue thicknesses of living humans [10,11]. They found a significant increase in tissue thickness of 50-60% directly following the embalming process, which is reduced by about 20% over the next 6 months. The tissue thicknesses of cadavers, which have been embalmed for over 6 months, lie approximately midway between these extremes of tissue dehydration and recently embalmed cadavers. Thus, they concluded that using cadavers that have been embalmed for over 6 months may be preferable to using unembalmed cadavers or recently embalmed cadavers, if the results are to be applied to a living population. The embalming process effectively rehydrates the tissue and embalmed cadavers may be more representative regarding tissue thicknesses of living people than tissues of recently deceased cadavers [12].

Previous studies have not considered that the thickness of tissue above the GPA might be adequate to harvest graft tissue in the area above the GPA. As gingival grafts are daily procedures during oral and periodontal plastic surgery, it is essential to determine the exact location of the GPA as in courses anteriorly in the palatal groove from the GPF to the incisive canal. The goal of the present study was to locate the position of the GPA in relation to surrounding anatomical landmarks and determine if the tissue thickness covering the GPA is sufficient to permit gingival grafts to be obtained for periodontal plastic surgery procedures in the area close to the GPB.

2. METHODS AND MATERIALS

The College of Medical Sciences, Department of Anatomy, of Nova Southeastern University provided 10 embalmed human cadaver hemifaces for all measurements in this study. These bodies have been donated to NSU for scientific purposes. In the anatomy laboratory, craniotomies of the cadavers were performed followed by sagittal bisection through the maxilla, horizontal plates and central incisors and the resultant hemifaces have already been used for educational purposes.

Cadaver dissections were performed on a total of ten (n=10) cadaver hemifaces of which [7] were partially and [3] were completely edentulous. It was not possible to accurately determine the gender of the hemifaces, hence no anatomical gender differences between males and females in the GPA could be investigated. To ensure a starting location distal to the greater palatine foramen, a vertical incision past the junction of the hard and soft palate was performed from the median palatine raphe all the way to the midline of the alveolar ridge using a No. 15 scalpel blade. Following this, the masticatory mucosa was sectioned until the greater palatine foramen was detected. From the greater palatine foramen to the incisive foramen, the palatal tissues of the cadavers were dissected into vertical slices of 3 mm in width perpendicular to the median palatine raphe using a double-bladed scalpel (Fig. 1).

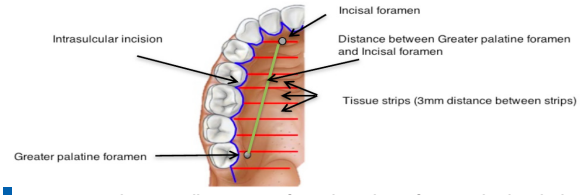

Figure 1. Schematic illustration of a cadaver hemiface marked with the location of the greater palatine foramen, incisive foramen, intrasulcular incision and several tissue slices (from http://3dsciencepics.com/tag/palate).

On each tissue slice, the following measurements were performed (Figs. 2 and 3):

1. Distance from the epithelial surface to the superior border of the GPA.
2. Diameter of GPA.
3. Distance from the inferior border of the vessel to the palatal bone.
4. Total thickness of the slice at the location of the GPA.
5. Distance from median palatine raphe to the GPA.
6. Distance from the CEJ of the teeth directly to the GPA in dentate cadavers.
7. Distance from the midline of the alveolar ridge directly to the GPA in edentulous cadavers.

Figure 2. Sectioning of cadaver palate into multiple vertical slices of 3 mm in width using a double bladed scalpel.

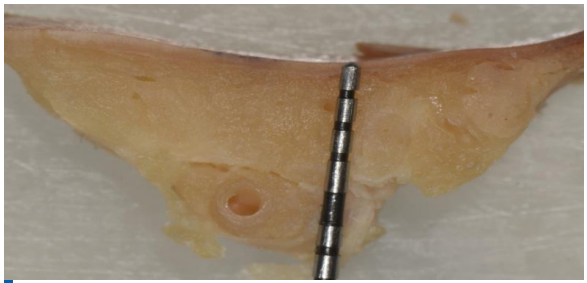

Figure 3. Soft tissue slice displaying measurements of the epithelial surface to the GPA, diameter of the vessel and distance to the bone using a periodontal probe.

All measurements were completed using a periodontal probe and a digital caliper. The digital caliper was used to obtain an exact result, while the periodontal probe was used to evaluate the clinical applicability of the findings. In completely edentulous cadavers, the midline of the entire

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alveolar ridge was marked with a thin black permanent marker. Perpendicular to the line marking the midline of the alveolar ridge, all missing teeth were marked, calculated from the average mesiodistal tooth diameter measurements.
All measurements were correlated to each other, the head length of the cadavers, the angle of the palatal vault and an estimate of the palatal depth.

2.1 Head length
The length of each cadaver's head was measured in a straight line from the glabella point of the forehead (g) to the most posterior point (opisthocranion, op) of the cranium in the midsagittal plane using a spreading caliper. The measurements for the head length were related to the different parameters and measurements taken on each slice.

2.2 Angle of palatal vault
Before any dissections were performed, alginate impressions of all cadaver hemifaces were taken and poured into microstone in the laboratory. Heavy body impression material was applied to the casts at the palatal vault, where the alveolar process meets the palatal process above the greater palatine foramen and GPA. The angle of the palatal vault was measured by using a protractor that was applied to slices of obtained impression of the palatal vault. The steepest angle was taken as the angle of the palatal vault. The angle of the palatal vault was related to the other tissue measurements.

2.3 Estimate of palatal depth
In addition, the depth of the palatal vault was estimated by two examiners and divided into shallow, average and steep according to the investigation by Reiser et. al [2]. The estimation of the palatal vault was then correlated to the various tissue measurements.
This study has a correlational pilot study design. Appropriate measures of central tendency (e.g. mean) and dispersion (e.g. standard deviation - SD) were calculated. ANOVA statistics at a $P < 0.05$ significance level to identify correlations was performed.

3. RESULTS

The average of all measurements was performed with respect to the opposing teeth in all the subjects. Measurements starting from the 3rd molar to the lateral incisor using a probe are displayed using a periodontal probe (Tab. 1) and a digital caliper (Tab. 2).
The comparison of the measurements of the periodontal probe and the digital caliper for all the measured variables were not statistically significantly different ($P > 0.10$, Power 0.35). Thus, the results are displayed as an average of the caliper measurements.

Table 1. Average measurements of the measurements with respect to the opposing teeth using a periodontal probe in all subjects. Probe 1 = Distance from the epithelial surface to the superior border of the GPA; Probe 2 = Diameter of the GPA; Probe 3 = Distance from the inferior border of the vessel to the palatal bone; Probe 4 = Total thickness of the slice; Probe 5 = Distance from the median palatine raphe to the GPA; Probe 6 = Distance from the CEJ to the GPA; Probe 7 = Distance from the midline of the alveolar ridge to the GPA.

Tooth		Probe.1	Probe.2	Probe.3	Probe.4	Probe.5	Probe.6	Probe.7
3rd Molar	Mean	5.17	1.42	0.42	7.00	13.00		12.50
	SD	1.26	0.14	0.52	0.87	1.41		
	Min	4.00	1.25	0.00	6.50	12.00		12.50
	Max	6.50	1.50	1.00	8.00	14.00		12.50
2nd Molar	Mean	6.21	1.36	0.29	7.83	12.22	12.90	12.00
	SD	1.11	0.28	0.39	1.14	1.49	1.74	1.00
	Min	4.50	1.00	0.00	5.75	9.50	10.50	11.00
	Max	8.50	2.00	1.00	10.00	15.00	15.00	13.00
1st Molar	Mean	4.78	1.22	0.38	6.38	11.10	12.92	11.77
	SD	1.52	0.41	0.45	1.57	1.77	1.91	2.06
	Min	3.00	0.50	0.00	3.75	8.00	9.00	8.00
	Max	8.50	2.00	2.00	11.00	14.50	15.00	15.00
2nd Premolar	Mean	3.30	0.95	0.75	5.00	8.98	12.56	11.50
	SD	0.65	0.28	0.39	0.70	2.55	2.62	1.38
	Min	2.00	0.50	0.00	4.00	4.50	7.50	9.50
	Max	4.50	1.50	1.50	6.50	15.00	15.00	13.50
1st Premolar	Mean	3.10	0.78	0.43	4.31	7.71	9.00	10.89
	SD	0.54	0.26	0.29	0.65	2.55	2.28	1.54
	Min	2.00	0.25	0.00	3.00	3.00	6.00	7.50
	Max	4.00	1.00	1.00	6.00	12.00	12.50	12.50
Canine	Mean	2.95	0.89	0.61	4.45	6.50	7.90	8.83
	SD	0.69	0.28	0.32	0.93	1.91	0.42	1.81
	Min	2.00	0.50	0.25	3.25	3.50	7.50	6.50
	Max	4.00	1.50	1.00	6.50	9.50	8.50	11.00
Lateral Incisor	Mean	3.00	0.50	0.75	4.25	6.00		4.50
	SD	0.71	0.00	0.35	0.35	0.71		0.00
	Min	2.50	0.50	0.50	4.00	5.50		4.50
	Max	3.50	0.50	1.00	4.50	6.50		4.50

Table 2. Average measurements of the measurements with respect to the opposing teeth using a digital caliper in all subjects. Caliper 1 = Distance from the epithelial surface to the superior border of the GPA; Caliper 2 = Diameter of the GPA; Caliper 3 = Distance from the inferior border of the vessel to the palatal bone; Caliper 4 = Total thickness of the slice; Caliper 5 = Distance from the median palatine raphe to the GPA; Caliper 6 = Distance from the CEJ to the GPA; Caliper 7 = Distance from the midline of the alveolar ridge to the GPA.

Tooth		Caliper.1	Caliper.2	Caliper.3	Caliper.4	Caliper.5	Caliper.6	Caliper.7
3rd Molar	Mean	5.04	1.34	0.52	6.92	13.77		16.18
	SD	1.09	0.08	0.37	0.93	1.67		3.32
	Min	4.00	1.27	0.28	6.28	11.97		12.87
	Max	6.17	1.42	0.95	7.98	15.28		19.50
2nd Molar	Mean	6.25	1.39	0.28	7.89	13.23	14.38	13.18
	SD	1.09	0.28	0.40	1.15	2.50	2.64	2.33
	Min	4.47	0.72	0.00	5.69	9.07	10.03	10.49
	Max	8.57	1.79	1.13	10.05	18.42	19.14	15.84
1st Molar	Mean	4.78	1.24	0.37	6.39	11.98	13.88	11.71
	SD	1.54	0.40	0.44	1.59	2.45	2.05	1.95
	Min	2.76	0.52	0.00	3.72	8.02	8.99	8.04
	Max	8.72	1.94	2.06	10.97	16.45	16.19	14.59
2nd Premolar	Mean	3.30	1.04	0.70	5.02	8.94	12.74	11.55
	SD	0.64	0.30	0.32	0.69	2.58	2.39	1.41
	Min	2.02	0.50	0.00	3.96	4.66	7.85	9.55
	Max	4.41	1.66	1.29	6.32	14.90	14.85	13.87
1st Premolar	Mean	3.13	0.80	0.42	4.32	7.75	9.05	10.88
	SD	0.59	0.24	0.28	0.60	2.46	2.24	1.61
	Min	1.94	0.40	0.00	3.11	3.17	5.72	7.23
	Max	4.24	1.18	0.92	5.89	11.81	12.42	12.56
Canine	Mean	2.95	0.91	0.51	4.42	6.56	7.83	8.67
	SD	0.67	0.20	0.23	0.96	1.93	0.36	1.71
	Min	1.92	0.62	0.27	3.35	3.50	7.37	6.24
	Max	3.96	1.38	0.89	6.58	9.43	8.29	10.68
Lateral Incisor	Mean	2.92	0.72	0.65	4.27	6.02		4.52
	SD	0.46	0.16	0.25	0.26	0.83		0.47
	Min	2.59	0.61	0.47	4.08	5.43		4.19
	Max	3.24	0.83	0.83	4.45	6.60		4.85

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The tissue thickness above the greater palatine artery decreased consistently from the 3rd molar to the canine area with the thickest mean tissue being in the 2nd molar region with 6.25 mm and shallowest mean tissue thickness in the region of the lateral incisor with 2.92 mm (Fig. 4).

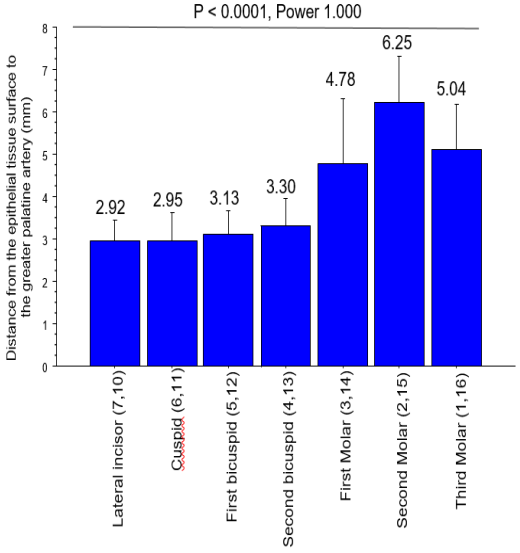

Figure 4. Bar chart of palatal tissue thickness by adjacent tooth type.

The total palatal tissue thickness followed a similar pattern as noted with the thickness of tissue over the artery with the smallest diameter in the lateral incisor region (4.27 mm) and thickest tissue found in the posterior with the thickest tissue in the second molar region (7.89 mm). The total palatal tissue thickness in the other sites presented to be canine (4.42 mm), first premolar (4.32 mm), second premolar (5.02 mm), first molar (6.39 mm) and third molar (6.92 mm). The mean diameter of the GPA ranged from 0.72 mm to 1.39 mm with the biggest diameter measured in the second molar and the smallest diameter in the lateral incisor region and a total range of 0.40 mm to 1.94 mm. The distance of the GPA to the bone ranged on from 0 mm to 2.06 mm and was on average less then 1 mm away from the bone throughout palate. The furthest distance of the GPA from the bone was detected in the second premolar region (0.70 mm) and the closest distance in the second molar region (0.28 mm) (Tab. 2).

The distance from the median palatine raphe or median palatine suture to the GPA was displayed to range from 3.17 mm to 18.42 mm with a total average of 10.34 mm. The distance increased consistently from anterior to posterior with the greatest distance on average being in the region of the 3rd molar with 13.77 mm and the smallest distance in the region of the lateral incisor with 6.02 mm. The distance from the CEJ directly to the GPA ranged on average from 13.88 mm to 14.38 mm in the molar region and 9.05 mm to 12.74 mm in the premolar region. The distance from the midline of the alveolar crest directly to the GPA ranged on average from 11.71 mm to 16.18 mm in the molar region and 10.88 mm to 11.55 mm in the premolar region. The distance of the GPA from the median palatine raphe ranged on average from the shortest distance of 6.02 mm in the lateral incisor region to the greatest distance of 13.77 mm in the 3rd molar region (Tab. 2).

A significant correlation (R2=0.92) was found between the total palatal tissue thickness and tissue thickness above the GPA. The correlation R2 was excellent at 0.916, suggesting that few other variables are involved in the relationship (Fig. 5).

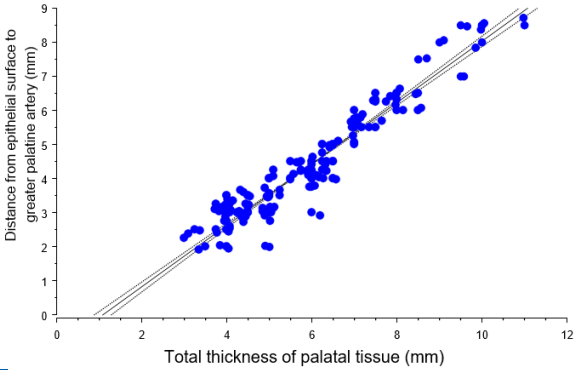

Figure 5. Regression plot of the total thickness of the palatal tissue, and distance from the epithelial surface to greater palatine artery.

From this finding a regression formula was derived calculating the tissue thickness above the artery using the total tissue thickness: Tissue thickness above the artery = (Total palatal tissue thickness – 0.967) x 0.9. The tissue thickness above the greater palatine artery is 1mm less than the total tissue thickness and the GPA does not deviate much more than approximately one mm from the palatal bone.

No statistically significant correlations were found between the angel of the palatal vault, the estimate of the palatal depth and the head length.

4. DISCUSSION

The purpose of the present investigation is to locate the position of the GPA in relation to surrounding anatomical landmarks and determine if the tissue thickness covering the GPA is sufficient to permit gingival grafts to be obtained for periodontal plastic surgical procedures in this area.

All measurements in the current investigation were performed using a digital caliper and a periodontal probe. It was demonstrated that there was no statistically significant difference between these two measurement tools for all the measurement variables ($P > 0.10$). Thus, our results will be applicable when using a periodontal probe in a clinical situation within the range of its scale.

The current investigation revealed that the average tissue thickness above the GPA, measured from the epithelial surface to the superior border of the vessel including the 2nd molar to the lateral incisor region, was found to be 4.29 mm using a periodontal probe and 4.30 mm using a digital caliper, ranging from 2.00 – 8.50 mm and 1.92 – 8.72 mm using a probe and caliper respectively. These results are in accordance with the investigation by Cho et al. who

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performed a histological analysis of 32 cadavers and showed that the overall distance from the surface of the palatine mucosa to the center of endothelium of the GPA in the canine to the 1st molar region was 4.31 ± 2.07mm [13].

To ensure survival of a FGG on the recipient site, a graft ranging between 0.75 – 1.25 mm in thickness is required which was determined by the histological study of Soehren et al (1973) [14]. Hence it was shown by the results of this study that with an average 4.30 mm tissue thickness above the GPA (ranging from 2.00 – 8.50mm), there is sufficient tissue thickness from the epithelial surface to the GPA in the entire palate to permit gingival grafts of 1 – 1.5 mm in thickness [2,14-17] to be obtained for FGG without risking injury to the GPA when meticulous surgical skills are applied. According to these measurements, bleeding issues in relation to the main branch of the GPA can be avoided if these boundaries are maintained. However, there are multiple smaller branches of the GPA that have been detected during this investigation, which could not be included and frequently course closer to the tissue surface; therefore, bleeding incidents during surgical procedures on the palate cannot entirely be prevented.

When it comes to harvesting CTG from the palate, different techniques have been described to obtain an adequate amount of graft tissue of 1 - 1.5 mm [17,18] or 1.5 - 2 mm [19] in thickness, but at the same time leaving a sufficiently thick amount of palatal fibromucosa in order to preserve blood supply of the undermined superficial flap [20]. Studies reported that the epithelial thickness on the palate ranges from 0.1 - 0.6 mm [14], 0.11 - 0.82 mm [21] or 0.30 - 0.41 mm [13]. Thus, to maintain vascularization of the undermined superficial flap and avoid tissue sloughing and the concomitant patient morbidity such as delayed healing, post-operative pain and discomfort, the thickness of the remaining flap must at least exceed the thickness of the epithelium and leave enough connective tissue for blood supply. It has been proposed, as a general rule, that at least 3 mm of tissue thickness is needed to provide a CTG of adequate thickness of 1 to 2 mm [22,23] and at the same time leave an adequate layer of epithelium and connective tissue to ensure sufficient blood supply to the access flap at the donor sit [24,25] In the current study, the average distance from the epithelial surface to the GPA in the third molar region, presented to be 5.04 mm, ranging from 4.00 to 6.17 mm. It increased in the second molar region with an average of 6.25 mm, ranging from 4.47 to 8.57 mm. Following the 2nd molar region anteriorly, it continuously decreased from the first molar region onwards. In the second and first premolar region, the mean thickness above the GPA presented with 3.30 mm and 3.13 mm respectively and approached ≤ 3 mm from the canine region forward (Fig. 4). This is in accordance to the results by Cho et al (2013) [13] and Kim et al (2014) who found that the shortest distance between the palatal masticatory mucosa and the GPA in the 2nd molar region was 5.7 ± 2.2 mm, in the 1st molar region 4.2 ± 1.4 mm [26]. In contrast to our results, their measurements reduced already to less than 3 mm from the 2nd premolar anteriorly [26]. From the results of our study, Kim et al. [26] and Cho et al. [13], it can be concluded, that the greatest tissue thickness above the GPA can be found starting from the 1st molar and posterior to it. According to the results of the current study, it was determined that the area of the first molar and posterior to it is suitable for obtaining donor tissue for connective tissue grafts in periodontal mucogingival surgeries staying above the GPA if a depth of 3 mm is not exceeded. This means that the donor site for obtaining palatal grafts can be extended in a medial and posterior direction and much larger size palatal graft can be obtained in one single surgery, possibly avoiding the contralateral side. Thus, not only the number of donor sites can be reduced but also the patients' postoperative morbidity. In addition, incidents of paresthesias and anesthesias is greater when graft tissue is harvested from the anterior palatal region, which is another reason to extend donor sites in a posterior direction. Nevertheless, just like previously mentioned when harvesting FGGs, there is always a risk of injuring any of the multiple smaller branches of the GPA.

Previous studies have not assessed the distance from the GPA to the palatal bone as the artery courses anteriorly from the greater palatine foramen. It was shown in the current investigation, that the distance from the vessel to the bone revealed to be an average of 0.47 mm ranging from 0.0 – 2.06 mm. It followed at a consistent distance to the palatal bone, on average never deviating more than one mm from the bone throughout the entire palate. Furthermore, it was shown by the results of this investigation that both the tissue thickness above the GPA and the total palatal tissue thickness increased from anterior to posterior. Correlation analysis showed an excellent correlation between these two parameters of $R2 = 0.92$, which means that the thicker the tissue the further away the artery is from the tissue surface (Fig. 5). From this finding a regression formula was derived calculating the tissue thickness above the artery using the total tissue thickness: Tissue thickness above the artery = (Total palatal tissue thickness – 0.97) x 0.9.

This means that the artery does not appear to ascend to the epithelial surface within the tissue but stays close to the palatal bone. Knowing that the GPA never deviates much more than one mm from the palatal bone and applying the total tissue thickness into our formula, this formula could be of clinical significance as a predictable way to calculate the location of the GPA in the palatal tissue. Two practical clinical implications can be derived from this finding. Firstly, after obtaining the total tissue

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thickness through bone sounding [27] or CBCT analysis [28,29], the regression formula can be used to determine if a site is suitable as a donor site for soft tissue grafts and avoid injuries to the GPA. Secondly, during an accidental injury of the GPA, it is important to insert the suture needle close to the palate bone when attempting to ligate it and not just place it anywhere within the tissue. There is a high risk to pierce the artery instead of ligating it otherwise. This is especially critical in the posterior region as the artery was found to be closest on average to the palatal bone in the second molar region with a mean of 0.28 mm.

Clinicians often refrain from utilizing donor tissue close to the GPF and along the entire course of the GPB to avoid sequelae involved with these injuries. Several studies have established guidelines on how to estimate the distance between the teeth and the GPA. [3,4,9] Reiser et al. (1996) and Benninger (2012) found the distance between the CEJ of the 1st molars and the GPA to range from 7 - 17 mm [3] and 9 - 16 mm [4] respectively. The range of the current study of the distance of the CEJ directly to the GPA of 5.72 - 19.14 mm is much greater compared to these previous findings. However, whereas Reiser et al. performed average measurements to the GPA primarily from the CEJs of the premolar and molar region, [3] and Benninger took only the first molar distance to the GPA into consideration [4], the current study demonstrated distances for each tooth separately including the second molar to the lateral incisor region. Fu et al. detected in their study similar measurements of the mean vertical distance from the GPB to the CEJ of the first molar with 13.1 ± 2 mm to our results of 13.88 mm [30]. With respect to the first premolar and canine distances to the GPA, our measurements were resembling those of the investigation by Cho et al. with 9.21 ± 2.55 mm and 7.76 ± 2.43 mm respectively. Our data agree with the recommendation of Cho et al., that "careful consideration is required during any surgical procedure involving the anterior region of the first premolar"[13]. Not only does the artery run closer to the teeth, but also is the tissue thickness above the artery reduced in the anterior area. These conclusions are in contrast with the recommendations of Dridi et al. (2008), who suggest the choice of harvest sites must favor the premolar or incisive-canine regions [9]. Despite the fact that there is an increased risk for injury in the anterior region, one must also bear in mind that the diameter of the artery is considerably reduced compared to the posterior region and homeostasis is achieved more predictably. Regarding harvesting grafts from the posterior palate, our conclusions are consistent with those of Klosek et al. (2009). The area more posterior on the palate, between the maxillary first premolar and second molar, was more suitable for harvesting CTG [31]

Three edentulous cadavers were included in the present investigation. No significant difference was found between dentate or edentulous subjects with respect to all variables (P-value = 0.44) and particularly when examining measurements on each tissue slice (P = 0.84). An additional dimension was added in the current investigation to be able to estimate the location of the GPA independent of the presence of teeth such as in partially and completely edentulous patients. This measurement was the distance from the median palatine raphe or median palatine suture to the GPA. The study correlated the measurements of the GPA to the patients' anatomical feature such as the length of the patients' head, the angle of palatal vault and an estimation of the palatal depth. No relationship between these features and the measurements was found in the current investigation. The limitations of the study include a small sample size of only 10 cadaver hemifaces and the fact that the study was executed on embalmed cadaver tissue and not on living tissue.

5. CONCLUSION

Several clinically relevant conclusions can be drawn from this descriptive pilot study. Firstly, a formula has been derived calculating the tissue thickness above the artery based on the total tissue thickness: Tissue thickness above the artery (in mm) = (Total palatal tissue thickness – 0.97) x 0.9. Through this formula it can be concluded that the GPA never deviates much more than one mm from the palatal bone which is helpful in predicting the location of the GPA when harvesting soft tissue for soft tissue graft procedures. Secondly, the results of our study revealed that the gingival tissue thickness above the GPA is adequate to harvest FGGs of 1 - 1.5 mm in thickness in the entire palate without risking injury to the GPA. Furthermore, donor tissue above the GPA for 1.5 mm thick CTGs with a 1.5 mm flap can be obtained from the 1st molar and posterior to the 1st molar. The thickest tissue thickness above the GPA was found above the 2nd molar region and the smallest above the lateral incisor/canine region. Thus, donor sites for palatal grafts can be extended in a medial and posterior direction and much larger size palatal graft can be obtained in one single surgery, if a depth of 3 mm is not exceeded.

Finally, measurements from the median palatine raphe or median palatine suture to the GPA provide a new landmark to reliably locate the GPA. This new landmark can assist the clinician to more reliably locate the GPB at various locations on the palate.

AUTHOR CONTRIBUTIONS

NMKC initiator and author of the study; WBP Data gathering, critically revising the manuscript, advisement and mentoring of first author; DB, MAH and JBS Advisement and mentoring of first author.

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Dr. Cunningham has been working as a Periodontist and Implant Specialist at Sage Dental Group, South Florida since 2015 and lives with her husband and 2 children in Fort Lauderdale.

Questions

1. The greatest tissue thickness above the GPA can be found:

❑a. In the 3rd molar region;
❑b. In the 2nd molar region;
❑c. In the premolar region;
❑d. In the canine region.

2. Which statement is not correct:

❑a. The GPA can be expected to be located within one mm from the palatal bone;
❑b. The tissue thickness above the GPA and the total palatal tissue thickness increase from anterior to posterior;
❑c. Donor tissue above the GPA for 1.5 mm thick CTGs with a 1.5 mm flap can be obtained from the 1st molar and posterior to the 1st molar;
❑d. The GPA courses anteriorly in the palatal groove consistently at 2 mm from the tissue surface.

3. There is sufficient tissue thickness from the epithelial surface to the GPA in the entire palate to permit gingival grafts of which thickness:

❑a. 0.25 - 0.5 mm;
❑b. 0.5 - 1 mm;
❑c. 1 - 1.5 mm;
❑d. 2.5 - 3 mm.

4. Possible sequelae from palatal graft procedures are:

❑a. Hemorrhaging;
❑b. Paresthesias;
❑c. Tissue sloughing;
❑d. All of the above.