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RESEARCH ARTICLE

PALATAL RUGAE: A BIOMARKER FOR DETERMINING THE POSITION OF ARTIFICIAL TEETH

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ABSTRACT

Purpose: The palatal rugae are a prominent stable landmark in the maxillary arch and its position lies constant throughout the life. Therefore it can be used as a guideline for the placement of artificial teeth in the maxillary arch. **Materials and Methods**: 150 subjects were randomly selected, 50 subjects of age group 20-40 years were taken for each arch form i.e. U shaped, V shaped and ovoid arch were selected and impressions were made. Materials used were maxillary dentulous casts, graphite pencil, metal scale, brass wire and divider. The length of palatal rugae, distance from palatal rugae to tip of canine, perpendicular distance from incisive papilla and midpoint of incisal surface to a line connecting 1st premolar and the distance from central incisor to incisive papilla were compared in all the 3 arch forms. **Results**: The length of 1st, 2nd and 3rd palatal rugae were statistically significant in ovoid, U and V shaped arches. The distance from end of first palatal rugae to tip of canine was more in ovoid arch when compared to U shaped arches and V shaped arches. The distance from incisive papilla to midpoint of central incisors in ovoid arch, U shaped arch, V shaped arch was not so significant. The Distance from posterior point of incisive papilla to perpendicular line connecting from premolars in ovoid, U shaped arch, V shaped arch was not so significant. **Conclusion**: In U shaped arches which appear broad mesio distally, square incisor teeth can be used. In ovoid arch, medium sized teeth were ovoid incisor teeth can be used. In V shaped arch as it is narrow and tapering mesio distally, tapering incisor teeth can be used. This study was therefore done to find out the position of teeth in relation to palatal rugae which in turn determines the selection of teeth accordingly.

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INTRODUCTION

Physiological tooth arrangement and aesthetic tooth placement is an important consideration in fabricating conventional complete dentures. Proper placement of teeth should be functional as well as aesthetically pleasing. Anterior teeth, especially maxillary anterior teeth, play a key role in achieving "improvement in patient esthetic value". A patient's existing dentures, pre-extraction radiographs, diagnostic casts and photographs made before the dentition is lost, may be useful in determining tooth position. In the absence of pre-extraction records, various guides have been used to select appropriately sized anterior teeth for edentulous patients. Facial anatomical landmarks can be used as guides include the inter-commissural width, inter-pupillary width, inter-alar width, and inner-canthal distance (Sellen, 1999; Harper, 1948). The incisive papilla is one of the more stable landmarks remaining unchanged after anterior teeth extraction and subsequent resorption of the maxillary ridge (Harper, 1948). Therefore, in the absence of pre-extraction records, the papilla can serve as an anatomical landmark and as a useful guide for assessing the original positions of maxillary anterior teeth.[2,3]. The incisive papilla otherwise known as palatine papilla is a small pear or oval shaped mucosal prominence situated at the midline of the palate, posterior to the palatal surface of the central incisors. The midpoint of the incisive papilla is more commonly used as a reference point, although the posterior part is more stable, as it undergoes least change after the teeth have been extracted (Panjwani, 2013). According to the Glossary of Prosthodontic Terms-8, Rugae are anatomical folds or wrinkles the irregular fibrous connective tissue located on the anterior third of the palate. They are also called "plica palatinae" or "rugae palatine (Glossary of prosthodontics terms)." They are asymmetrical and irregular elevations found in the anterior one third of the palate. They develop around the third month of intrauterine life from the connective tissue of the palatine process of the maxillary bone. The growth and development of the rugae are controlled by mutual epithelio-mesenchymal interactions and specific extra cellular matrix molecules are spatially expressed. It develops from the lateral membrane of the incisal papilla in a transverse direction along the mid saggital plane (Solomon, 2012). The rugae also play an important role in forensic dentistry, as they are protected from trauma and high

temperatures due to their internal position in the oral cavity, surrounded and protected by lips, cheeks, tongue, teeth and bone.[6,7] There may be different forms of arches where the teeth shows spacing or crowding, which may require the selection of appropriate shape of the teeth accordingly. But there is little information concerning the relationship of palatine rugae to artificial teeth selection. Boucher stated that "a study that would search for a relationship between the upper cuspids and the rugae might be worth the effort (Textbook of complete denture- boucher). So the purpose of this study is to find if any correlation exists between various palatal rugae measurements, incisive papilla and maxillary anterior tooth positions. The palatal rugae pattern in u, v and ovoid arches, the distance from central incisor to incisive papilla, the length of 1st, 2nd and 3rd palatal rugae, the distance from the end of first palatal rugae to tip of canine, distance from incisive papilla to midpoint of central incisor, distance from posterior most point of incisive papilla to line connecting premolars and to measure perpendicular distance from midpoint of incisal surface to a line connecting premolar were to be assessed.

MATERIALS AND METHODS

Materials required were maxillary dentulous casts, divider, stainless steel scale, alginate impression material and digital vernier calliper (Figure 1,2). An inclusion criterion includes completely dentulous subjects with all teeth present till 2nd molar without crowding, spacing or malaligned teeth. Adult males and females of age group 20- 40 years. Patients with any missing teeth in upper anterior region or any prosthesis or palatal defect in the maxillary arch should be excluded. Considering the above inclusion and exclusion criteria, 150 subjects were randomly selected 50 subjects having U shaped arch, 50 subjects having V shaped arch and 50 subjects having ovoid arch forms were taken (figure 4). After doing a brief oral examination, proper sized perforated rim lock stock tray (S. S. WHITE) will be selected and customization of tray was done where necessary. Impressions were made and the cast was poured immediately with hard setting dental stone (TYPE III). Arch contour is identified using sym grid (Figure 5). This instrument is used to measure the transversal and sagittal dental arch symmetry of the study model which was measured from the occlusal view. The symmetry analysis determines the dental position differences of the left and right dental arch in the transversal and sagittal orientation.

The measurements on the dentulous cast were made in the following way: Digital vernier calliper (with 0.01 mm accuracy) was used for the vertical and sagittal cast measurements.

Distance from the end of first palatal rugae to tip of canine (Figure 6): It was measured from the tip of the canine to the first palatal rugae.

Length of third palatal rugae: The distance between the two lateral points were measured using a vernier calliper.

Length of second palatal rugae: The distance between the two lateral points were measured using a vernier calliper.

Length of first palatal rugae: The distance between the two lateral points were measured using a vernier calliper.

Distance from incisive papilla to midpoint of central incisor (Figure 7): The posterior-most point of incisive papilla and the midpoint of the incisal surface of both the right and left central incisors were identified and measured using vernier calliper.

Figure 1. Materials

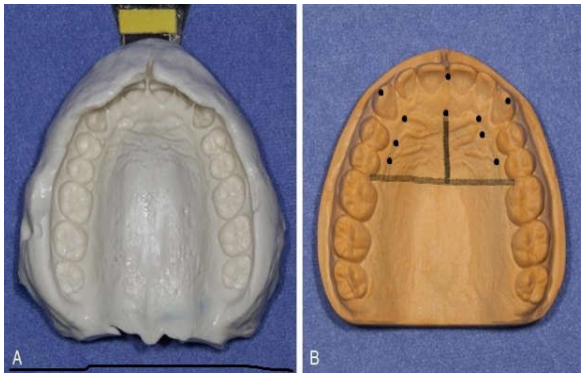

Figure 2. Maxillary dentulous cast

Figure 3: Maxillary dentulous casts

Figure 4. Markings made on the casts

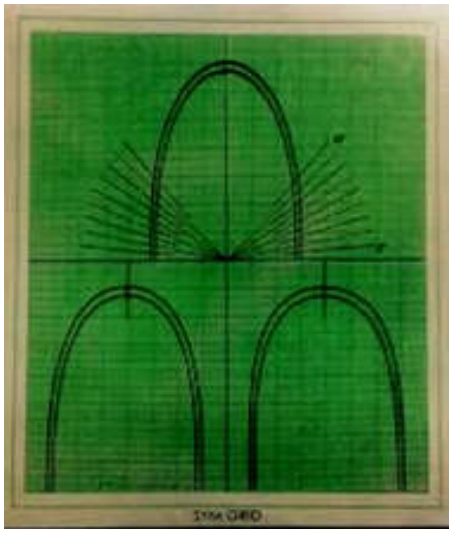

Figure 5. Sym grid used for arch analysis

Figure 6. Distance from the 1st palatal rugae to the tip of the canine

Figure 7. Distance from the incisial papilla to central incisors

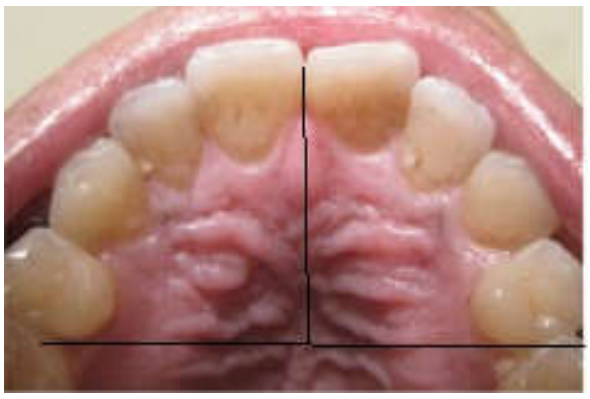

Figure 8. Distance from the incisal surface of central incisors to line connecting premolars

Perpendicular distance from incisive papilla to a line connecting the first premolars (Figure 8): The posterior-most point of incisive papilla and the central point of the first premolars on both sides were identified and the central point of first premolar on both right side and left side to the posterior-most point of incisive papilla were measured using vernier calliper.

Perpendicular distance from midpoint of incisal surface to a line connecting premolar: The midpoint of the incisal surface of both the right and left central incisors will be identified and from the central point of first premolar of right and left side, a perpendicular line was drawn and the distance is measured using vernier calliper.

RESULTS

After obtaining the maxillary dentulous casts, the above mentioned parameters were tabulated and statistically analysed. On Comparison of parameters for ovoid arch (Table 1) shows a mean value of 21.42 for length of 1st palatal rugae, 23.88 for length of 2nd palatal rugae, 25.56 for length of 3rd palatal rugae. The mean value for the distance from the end of 1st palatal rugae to tip of canine was 11.78, 10.48 for distance from incisive papilla to central incisors, 17.74 for distance from posterior point of incisive papilla to premolars, 28.22 for distance from incisal surface of central incisors to premolars. On Comparison of parameters for V shaped arch (Table 2) shows a mean value of 19.96 for length of 1st palatal rugae, 21.50 for length of 2nd palatal rugae, 23.88 for length of 3rd palatal rugae.

The mean value for the distance from the end of 1st palatal rugae to tip of canine was 11.42, 10.36 for distance from incisive papilla to central incisors, 16.90 for distance from posterior point of incisive papilla to premolars, 27.26 for distance from incisal surface of central incisors to premolars. On Comparison of parameters for U shaped arch (Table 3) shows a mean value of 21.10 for length of 1st palatal rugae, 23.28 for length of 2nd palatal rugae, 25.08 for length of 3rd palatal rugae. The mean value for the distance from the end of 1st palatal rugae to tip of canine was 10.96, 10.46 for distance from incisive papilla to central incisors, 17.10 for distance from posterior point of incisive papilla to premolars, 27.56 for distance from incisal surface of central incisors to premolars.

On comparison of mean between groups (ovoid arch, V shaped arch & U shaped arch) different parameters by using ANOVA & post hoc (Table 4) shows that the length of 1st palatal rugae for ovoid arch (21.42), V shaped arch (19.96) and U shaped arch (21.10) was highly significant. The length of 2nd palatal rugae for ovoid arch (23.88), V shaped arch (21.50) and U shaped arch (23.28) was highly significant. The length of 3rd palatal rugae for ovoid arch (25.56), V shaped arch (23.88) and U shaped arch (25.08) was highly significant. The distance from the end of 1st palatal rugae to tip of canine in ovoid arch (11.78), V shaped arch (11.42) and U shaped arch (10.96) was significant. The distance from the incisive papilla to central incisors in ovoid arch (10.48), V shaped arch (10.36) and U shaped arch (10.46) was not so significant. The distance from posterior point of incisive papilla to premolars in ovoid arch (17.10), V shaped arch (16.90) and U shaped arch (17.74) was not so significant. The distance from incisal surface of central incisor to premolar in ovoid arch (28.22), V shaped arch (27.26) and U shaped arch (27.56) was not so significant.

Parameters	Minimum	Maximum	Mean	SD
Length of 1st PR	18	24	21.42	1.43
Length of 2nd PR	19	29	23.88	2.61
Length of 3rd PR	21	28	25.56	1.76
Distance from end of 1st PR to TC	10	18	11.78	1.72
Distance from IP to CI	8	12	10.48	0.89
Distance from posterior point of IP to PM	11	21	17.74	2.03
Distance from incisal surface of CI to PM	21	31	28.22	2.19

Parameters	Minimum	Maximum	Mean	SD
Length of 1st PR	17	28	19.96	1.95
Length of 2nd PR	18	28	21.50	2.68
Length of 3rd PR	18	30	23.88	3.30
Distance from end of 1st PR to TC	7	14	11.42	1.23
Distance from IP to CI	8	13	10.36	1.37
Distance from posterior point of IP to PM	8	21	16.90	2.38
Distance from incisal surface of CI to PM	18	231	27.56	29.05

Parameters	Minimum	Maximum	Mean	SD
Length of 1st PR	19	28	21.10	1.75
Length of 2nd PR	20	29	23.28	2.47
Length of 3rd PR	21	31	25.08	2.30
Distance from end of 1st PR to TC	8	15	10.96	1.51
Distance from IP to CI	7	13	10.46	1.21
Distance from posterior point of IP to PM	10	21	17.10	1.97
Distance from incisal surface of CI to PM	19	31	27.56	2.58

Parameter	Groups	Mean	SD	P-value	Inference	Post HOC
Length of 1st PR	OVIOD ARCH	21.42	1.43	<0.01	HS	G1>G2 & G2<G3
	V SHAPED ARCH	19.96	1.95			
	U SHAPED ARCH	21.10	1.75			
Length of 2nd PR	OVIOD ARCH	23.88	2.61	<0.01	HS	G1>G2 & G2<G3
	V SHAPED ARCH	21.50	2.68			
	U SHAPED ARCH	23.28	2.47			
Length of 3rd PR	OVIOD ARCH	25.56	1.76	<0.01	HS	G1>G2 & G2<G3
	V SHAPED ARCH	23.88	3.30			
	U SHAPED ARCH	25.08	2.30			
Distance from end of 1st PR to TC	OVIOD ARCH	11.78	1.72	<0.05	S	G1>G3
	V SHAPED ARCH	11.42	1.23			
	U SHAPED ARCH	10.96	1.51			
Distance from IP to CI	OVIOD ARCH	10.48	0.89	0.86	NS	-
	V SHAPED ARCH	10.36	1.37			
	U SHAPED ARCH	10.46	1.21			
Distance from posterior point of IP to PM	OVIOD ARCH	17.74	2.03	0.13	NS	-
	V SHAPED ARCH	16.90	2.38			
	U SHAPED ARCH	17.10	1.97			
Distance from incisal surface of CI to PM	OVIOD ARCH	28.22	2.19	0.64	NS	-
	V SHAPED ARCH	27.56	29.05			
	U SHAPED ARCH	27.26	2.58			

DISCUSSION

Various anatomical landmarks were considered during arrangement of artificial teeth. Maxillary anterior teeth are arranged first followed by the posterior teeth arrangement. Anterior teeth are arranged in relation to the incisive papilla and canine prominence. For selection of anterior teeth size of face, form of the face, interarch-space, lip length and size of arch were commonly considered (Sellen, 1999; Harper, 1948). Harper et al has conducted a study to find the relationship between the maxillary central incisor and the incisive papilla found that the incisal edges of the maxillary central incisors should be 5-8 mm anterior to the papilla.[2] A study done by Panjwana et al found that the average distance between the anterior point of the central incisors and the centre of the incisive papilla was 7.7 mm (Panjwani, 2013). Bhandari et al described as 8-10 mm for this measurement. E.G.R. Solomon et al has conducted a study on Dravidian dentate subjects to relate incisive papilla to central incisors and canines and also to ascertain its shape (Solomon, 2012).

According to the results obtained from this study the distance from the incisal edges of maxillary central incisors to the incisive papilla in ovoid arch is 8-12mm, in V shaped arch is 8-13mm and in U shaped arch it is around 7-13 mm. Abdullah and shetty et al has conducted a study to find the relationship of central incisors and canines to incisive papilla. It was found that 57.6% of inter-canine lines passed through the centre of the papilla and they also suggested that an average distance of 12-13 mm from the posterior end of the papilla to the labial surface of central incisors and an inter-canine distance of 33-35 mm can be used as starting points. According to the results obtained from this study, the inter canine distance in ovoid arch was 32-35 mm, in V shaped arch 30-32 mm and in U shaped arch 28-32 mm. Kapali *et al.* has conducted a study which concluded that rugae should not be used as a guide in determining the position of maxillary canines, because in only half the patients did the rugae point towards the maxillary canines. But according to the results obtained from this study we can conclude that rugae can be used as a guide for

placement of artificial teeth and the length of 1st, 2nd and 3rd palatal rugae in V shaped arch, ovoid arch and U shaped arches were highly significant. The branching pattern of the lateral most ends of palatal rugae and the distance from the tip of canine to the first palatal rugae were highly variable in V shaped, ovoid and U shaped arches and therefore helps in selection of artificial teeth based on the arch form. The distance from the end of 1st palatal rugae to the tip of the canine is highly variant among ovoid (mean 11.78), V (mean 11.42) and U shaped arches (mean 10.96). H F grove and tucker et al has conducted a study to find the relation of maxillary canines to the incisive papilla which showed that in 92 % of patients the posterior margin of the papilla was located approximately 3 mm anterior to a baseline drawn between the distal contact points of the canines (Grove, 1989; Tucker, 1971). Almeida et al conducted a study to find the stability of palatal rugae as land marks for dental casts (Almeida, 1995). According to the results of this study palatal rugae can be used as a stable biomarker for the positioning of artificial teeth.

Ehrlich and Gaxit has conducted a study and found that in the ovoid and tapering arches the intercanine line passed predominantly through the centre of the papilla, or 1 to 3 mm posterior to the centre of the papilla. In the square arches the intercanine line passed either through the centre of the papilla, or 1 to 2 mm anterior to the centre of the papilla (Erlich, 1975). According to the results obtained from this study the inter canine distance in ovoid arch was 32-35 mm, in V shaped arch 30-32 mm and in U shaped arch 28-32 mm. The distance from the posterior part of incisive papilla to the perpendicular line connecting premolars was observed and it was not so significant in ovoid (mean 17.10), V (mean 16.90) and U (mean 17.74) shaped arches. Simmons et al studied the anatomic location of the incisive papilla to that of the maxillary anterior teeth and have measured the distance between the centre of the papilla and the labial surfaces of the central incisors which is approximately 10 mm.[15] According to the results obtained from this study the distance from the posterior end of papilla to the labial surface of central incisor in ovoid arch is 12-14mm, in V shaped arch 10-12mm and in U shaped arch 13-15 mm.

Grave et al has conducted a study and concluded that incisive papilla can be used as a guide for anterior tooth position.[16] According to the results obtained from this study we conclude that incisive papilla can be used as a guide for tooth positioning and varies by 8-13mm in V, U and ovoid arches. Philip et al in their study evaluated various methods for selecting anterior teeth such as incisive papilla and canine eminence. Incisive papilla in dentate subjects serves as a guide to develop facial contour in upper occlusal rim and anterior tooth position.[17] So, while arrangement of artificial teeth in their respective arches, care must have taken in selection of proper size and shaped teeth accordingly. Based on the length of 1st, 2nd and 3rd palatal rugae, the distance from the end of first palatal rugae to tip of canine, distance from incisive papilla to midpoint of central incisor, distance from posterior most point of incisive papilla to line connecting premolars and perpendicular distance from midpoint of incisal surface to a line connecting premolar the following conclusions are drawn:

- In U shaped arches which appear broad mesiodistally, squarish incisor teeth can be used.
- In ovoid arch, medium sized teeth i.e. ovoid shaped incisor teeth can be used
- In V shaped arch as it is narrow and tapering mesiodistally, tapering incisor teeth can be used.
- This study was therefore done to find out the position of teeth in relation to palatal rugae which in turn determines the selection of teeth accordingly.

Conclusion

Anatomical landmarks play very important role in arrangement of teeth. Placing anterior teeth in arch forms is guided by incisive papilla, canine prominence and palatal rugae. As the palatal rugae are a stable landmark which is not affected even after trauma or orthodontic tooth movement, it can be used as a guide for placement of anterior teeth. This will also guide in the selection of proper size and form of the artificial teeth set.

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