Reliability of palatal rugae patterns in individual identification

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Abstract

Background: Dental identification plays a major role in mass disaster identification of human remains. Palatal rugae can be used as a substitute for a comparative method of identification.

Materials and Methods: The present cross-sectional study was done with 137 pre- and post-orthodontically treated casts of patients, which were divided into 50 cases each of extraction and nonextraction and 37 cases of palatal expansion involving both extraction and nonextraction. Hydrocolloid (alginate) impression of the upper jaw of the patient was taken and then cast in the dental plaster of Paris material. Palatal rugae pattern was classified according to Lysellm, and Thomas and Kotze classification. Two Observers recorded the data, mean of two were taken for analysis.

Results: On the right side, there was no significant difference between the extraction and nonextraction groups; however, there was a rise in length in the nonextraction and palatal expansion groups. On the left side, there was little change between the nonextraction and palatal expansion groups, but the extraction group had a modest increase in length. Mean lengths compared within three groups revealed insignificant difference.

Conclusion: Palatal rugae pattern can be used in establishing identity in forensic medicine provided antemortem data are available. Orthodontic treatment has an impact on stability of palatal rugae. Most reliable and stable points being third rugae, they could be used as reference points to evaluate tooth movements

Keywords: Antemortem, forensic, hydrocolloid, orthodontic, palatal rugae

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INTRODUCTION

Forensic science is defined as the application of science to the law. It involves challenging processes such as accurate identification of the deceased and/or dead samples.[1,2] Visual recognition is the most common mode of identification in most of the circumstances.[3,4] However, it is not ideal in exceptional circumstances of death, such as those involving accidents, fire, decomposition or trauma, where

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postmortem alterations make identification impossible. Common forensic methods of identification under the circumstances are fingerprints, DNA profiling and dental comparison. Although finger prints is gold standard for human identification, its application limited under death due to burnt or decomposing remains or massive trauma.[5] Although DNA is very accurate in identification, it still has many limitations as it is a very expensive technique and always needs an antemortem record for comparison. It gets easily contaminated by extraneous DNA or destroyed by excessive heat. Furthermore, the DNA mining and documentation is an extensive process.[6,7]

Dental identification plays a significant role in mass adversity identification of human remains, helping in >90% of the mass disasters cases. Palatal rugae can be used as substitute identification. Studies that have been carried out on rugae showed highly unique rugae patterns and individuality throughout life. The palatal rugae are shielded from physical damage and temperature changes by their anatomical placement within the oral cavity – within the blanket of cheeks, lips, buccal pad of fat and dentoalveolar apparatus. Thus, it can be utilized as a trustworthy reference point during forensic identification. Palatal rugae identification can have a significant role in forensic identification during mass disasters, terrorist acts, traffic accidents and burnt victims, where it is difficult to use the normal identification methods.[8] There is no extensive published literature review on the palatine rugal identification, and most of the available studies are based on the classification systems designed by Lysell or Thomas and Kotze (1987).[9,10] There are very few studies to determine the reliability of rugae patterns in individual identification in forensic sciences/laboratories. Until now, there have been disagreements over the quantitative and qualitative characteristics of rugae after extraction, orthodontic therapy and denture prosthesis. Growth, extractions, palatal expansion or a combination of these factors may not have been taken into account in previous investigations. As a result, the goal of this study was to see how stable the palatal rugae pattern was after orthodontic treatment, both with and without extractions and palatal expansion.

MATERIALS AND METHODS

The present cross-sectional study was conducted in V S Dental College and Hospital, Bengaluru. The institute provided a total of 137 pre- and post-orthodontically treated casts of patients, which were categorized into 50 extraction and nonextraction cases each and 37 cases of palatal expansion comprising both extraction and nonextraction. The sample size of the participants was based on Johnson and Brook (2010). A simple random sampling procedure was used among the full list of patients

Inclusion criteria

Preadjusted edgewise treatment (duration 8–24 months) was used to treat all of the patients. Participants who are willing to provide consent were included.

Exclusion criteria

Patients with congenital malformation or defects of the palate and previous orthoganthic surgery were excluded from the study.

Methodology

The mouth of the patient was rinsed with mouthwash before taking the impression. An irreversible hydrocolloid (alginate) impression of the upper jaw of the patient was taken and then cast in dental plaster of Paris material. Calcor rugoscopy, or the overlay print of palatal rugae in a maxillary cast, can be used to perform comparative analysis. A very sharp (2H) pencil, illuminated magnifier and a Vernier scale were used to trace the palatal rugae on the plaster cast. The palatal rugae pattern was evaluated using the Lysell and Thomas and Kotze categorization systems. Rugae length was divided into three groups: rugae primaries (5 mm or more), secondary (3–5 mm), fragmentary (2–3 mm) and rugae measuring <2 mm that were not evaluated. Rugae forms were divided into eight key categories: "(1) annular, (2) branching, (3) converging, (4) cross-linking, (5) curved, (6) diverging, (7) linear and (8) wavy." Two observers tabulated the results and the mean of the two was used for analysis [Figure 1]. Rugae length, form and positions were measured and compared on both the right and left sides of pre- and post-treated orthodontic casts.

Statistical analysis

Results were tabulated in Microsoft excel sheet. Different groups were compared by ANOVA. Paired groups were

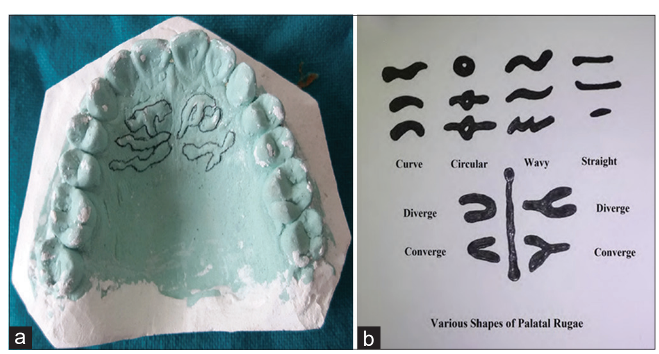

Figure 1: (a) Pencil marked tracing of the palatal rugae. (b) Different rugae shapes

Table 1: Mean and SD length in three groups

Group	Right Side				Left side			
	Pre-treatment		Post-treatment		Pre-treatment		Post-treatment	
	Means	SD	Means	SD	Means	SD	Means	SD
Extraction	8.7108	3.5109	8.7127	3.5205	8.5582	2.9954	8.3940	3.1709
Nonextraction	8.7505	3.4461	9.1361	4.0519	8.6702	3.3137	8.9042	3.3790
Palatal expansion	8.4921	3.3078	9.0155	3.5748	8.6515	3.1582	8.6382	3.3667

SD: Standard deviation

Table 2: Comparison of extraction, nonextraction and palatal expansion with respect to right side length by ANOVA test

Variable	Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	*F*	*P*
Pretreatment	Between groups	2	6.48	3.242	0.2755	0.7593
	Within groups	542	6377.96	11.767		
	Total	544	6384.45			
Posttreatment	Between groups	2	18.26	9.128	0.6518	0.5215
	Within groups	541	7576.38	14.004		
	Total	543	7594.63			
Change	Between groups	2	22.06	11.028	0.8289	0.4371
	Within groups	542	7211.23	13.305		
	Total	544	7233.29			

Table 3: Comparison of extraction, nonextraction and palatal expansion with respect to left side length by ANOVA test

Variable	Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	*F*	*P*
Pretreatment	Between groups	2	1.41	0.706	0.0706	0.9318
	Within groups	559	5589.54	9.999		
	Total	561	5590.95			
Posttreatment	Between groups	2	26.37	13.184	1.2074	0.2997
	Within groups	559	6103.78	10.919		
	Total	561	6130.15			
Change	Between groups	2	16.37	8.184	0.8428	0.4310
	Within groups	559	5427.83	9.710		
	Total	561	5444.20			

Table 4: Comparison of pre and posttreatment with respect to length values in three groups i.e., extraction, nonextraction and palatal expansion group in right side by paired *t*-test

Group	Treatment	Mean	SD	Mean difference	SD difference	Paired *t*-test	*P*
Extraction	Pre	8.7108	3.5109	−0.0019	3.0770	−0.0083	0.9934
	Post	8.7127	3.5205				
Nonextraction	Pre	8.7505	3.4461	−0.3855	3.9774	−1.3810	0.1688
	Post	9.1361	4.0519				
Palatal expansion	Pre	8.4959	3.3184	−0.5195	3.7826	−1.6990	0.0914
	Post	9.0155	3.5748				

SD: Standard deviation

compared by paired *t*-test. A $P < 0.05$ is considered statistically significant.

RESULTS

All three groups were equated for mean and standard deviation both right and left sides. On the right side, the extraction group showed little variation, whereas the nonextraction and palatal expansion instances showed increased length. On the left side, there was little change between the nonextraction and palatal expansion groups, but the extraction group had a modest increase in length [Table 1]. Insignificant differences in mean length within and between groups were detected from pre- to post-treatment when lengths were compared within three groups [Tables 2 and 3]. The paired *t*-test was used to compare changes in length in three groups [Tables 4 and 5]. On the right side, there was little variation in the nonextraction group, but there was an increase in length in both the extraction and palatal expansion groups. On the left side, the extraction and nonextraction groups had about comparable lengths, whereas the palatal expansion group had a small increase. For the comparison of changes in rugae pattern shape, the Chi-square test was used. On both the right and left sides, the palatal expansion and extraction groups showed the most alterations, while the nonextraction group showed the least [Tables 6 and 7]. The Chi-square test was used to compare the three groups

Table 5: Comparison of pre and posttreatment with respect to length values in three groups i.e., extraction, nonextraction and palatal expansion group in left side by paired *t*-test

Group	Treatment	Mean	SD	Mean difference	SD difference	Paired *t*-test	*P*
Extraction	Pre	8.5582	2.9954	0.1641	2.7161	0.8460	0.3986
	Post	8.3940	3.1709				
Nonextraction	Pre	8.6702	3.3137	−0.2340	3.3382	−1.0133	0.3121
	Post	8.9042	3.3790				
Palatal expansion	Pre	8.6515	3.1582	0.0133	3.2732	0.0510	0.9594
	Post	8.6382	3.3667				

SD: Standard deviation

Table 6: Comparison of three groups with respect to shape of rugae patterns at pre and posttreatment at right side

Treat	Rugae patterns	Extraction (%)	Nonextraction (%)	Pal extraction (%)	Total (%)	*P*
Pre	Annular	0 (0.00)	2 (0.98)	1 (0.65)	3 (0.55)	Chisquare=10.0120
	Branching	23 (12.23)	26 (12.75)	27 (17.65)	76 (13.94)	df=12
	Converging	11 (5.85)	10 (4.90)	8 (5.23)	29 (5.32)	*P*=0.61490
	Curved	62 (32.98)	50 (24.51)	45 (29.41)	157 (28.81)	
	Diverging	4 (2.13)	3 (1.47)	3 (1.96)	10 (1.83)	
	Linear	46 (24.47)	57 (27.94)	40 (26.14)	143 (26.24)	
	Wavy	42 (22.34)	56 (27.45)	29 (18.95)	127 (23.30)	
	Cross linking	188 (100.00)	204 (100.00)	153 (100.00)	545 (100.00)	
	Total					
Post	Annular	1 (0.53)	2 (0.98)	2 (1.31)	5 (0.92)	Chisquare=8.8041
	Branching	15 (7.98)	27 (13.24)	18 (11.76)	60 (11.01)	df=14
	Converging	20 (10.64)	11 (5.39)	11 (7.19)	42 (7.71)	*P*=0.84334
	Curved	53 (28.19)	56 (27.45)	42 (27.45)	151 (27.71)	
	Diverging	5 (2.66)	3 (1.47)	4 (2.61)	12 (2.20)	
	Linear	53 (28.19)	57 (27.94)	43 (28.10)	153 (28.07)	
	Wavy	40 (21.28)	47 (23.04)	31 (20.26)	118 (21.65)	
	Cross linking	1 (0.53)	1 (0.49)	2 (1.31)	4 (0.73)	
	Total	188 (100.00)	204 (100.00)	153 (100.00)	545 (100.00)	

Table 7: Comparison of three groups with respect to shape of rugae patterns at pre and posttreatment at left side

Treat	Rugae patterns	Extraction (%)	Non-extraction (%)	Pal extraction (%)	Total (%)	*P*
Pre	Annular	4 (2.04)	5 (2.39)	3 (1.90)	12 (2.13)	Chisquare=7.1482
	Branching	27 (13.78)	29 (13.88)	24 (15.19)	80 (14.21)	df=14
	Converging	4 (2.04)	7 (3.35)	3 (1.90)	14 (2.49)	*P*=0.92884
	Curved	52 (26.53)	58 (27.75)	31 (19.62)	141 (25.04)	
	Diverging	5 (2.55)	7 (3.35)	6 (3.80)	18 (3.20)	
	Linear	53 (27.04)	59 (28.23)	47 (29.75)	159 (28.24)	
	Wavy	47 (23.98)	42 (20.10)	42 (26.58)	131 (23.27)	
	Cross linking	4 (2.04)	2 (0.96)	2 (1.27)	8 (1.42)	
	Total	196 (100.00)	209 (100.00)	158 (100.00)	563 (100.00)	
Post	Annular	3 (1.53)	5 (2.39)	3 (1.90)	11 (1.95)	Chisquare=11.0042
	Branching	18 (9.18)	25 (11.96)	13 (8.23)	56 (9.95)	df=14
	Converging	5 (2.55)	6 (2.87)	3 (1.90)	14 (2.49)	*P*=0.68574
	Curved	62 (31.63)	61 (29.19)	53 (33.54)	176 (31.26)	
	Diverging	5 (2.55)	8 (3.83)	6 (3.80)	19 (3.37)	
	Linear	60 (30.61)	55 (26.32)	49 (31.01)	164 (29.13)	
	Wavy	37 (18.88)	48 (22.97)	30 (18.99)	115 (20.43)	
	Cross linking	6 (3.06)	1 (0.48)	1 (0.63)	8 (1.42)	
	Total	196 (100.00)	209 (100.00)	158 (100.00)	563 (100.00)	

across all three criteria. Approximately 89.19% and 84% of the study group displayed palatal expansion and extraction, respectively. Table 8 shows that 62% of the study individuals in the nonextraction group showed alterations ($P = 0.00041$)

DISCUSSION

The amount of tooth movement appears to have an effect on the palatal rugae's stability. In the current investigation, posttreatment changes in rugae size, shape, location, quantity and gross appearance were seen in the majority of cases. Statistical analysis with the length parameter revealed that they were not statistically significant on either side. Maximum alterations were noted in palatal expansion cases; however, they were not statistically significant. On both sides, the rugae's form was investigated. The rugae pattern changed the most in palatal expansion instances;

Table 8: Comparison of three groups with respect to status changes

Results	Extraction (%)	Non-extraction (%)	Palatal expansion (%)	Total (%)	*P*
Changed	42 (84.00)	31 (62.00)	33 (89.19)	106 (77.37)	Chisquare=10.9542
Not changed	8 (16.00)	19 (38.00)	4 (10.81)	31 (22.63)	df=2, *P*=0.00041, S
Total	50 (100.00)	50 (100.00)	37 (100.00)	137 (100.00)	

however, the changes between the research groups were not statistically significant.

When all of the parameters were combined and statistically analyzed, the changes were found to be statistically significant with a $P = 0.00041$, which differs from earlier research. The discrepancy in results with previous studies can be related to the fact that previous studies did not include palatal expansion cases, and case categorization was not done in a systematic manner.

The group with palatal expansion cases had the most significant alterations (89.19%), followed by the extraction group (84.00%), and the nonextraction group had the least significant changes (62.00%). Bansode and Kulkarni conducted a similar study and found results that were incongruent with our findings, which included only a few examples of palatal expansion.[7,11-13]

The palatal expansion cases in the study done by Bansode and Kulkarni showed changes only in the length of palatal rugae.[7,12,14,15] The first and second palatal rugae have limited stability and are reliant on the type of orthodontic treatment used. The closer the rugae are to the teeth, the more likely they are to extend in the direction that their associated teeth move, according to Peavy and Kendrick. These findings are also in line with Van der Linden's and Almeida *et al*.'s findings.[16-22]

There will be a large increase in arch perimeter in cases of palatal growth, resulting in alterations in the shape, size and location of rugae patterns. Premolar extraction creates a considerable room for distal retraction of maxillary anterior teeth, which shifts rugae placements. The third rugae were rather steady in all measurements, and their location in the molar region, away from the anterior teeth's distal retraction, may have contributed to this. These findings were similar to those of Schwarze and Peavy and Kendrick.[23-27] They came to the conclusion that the further back the rugae are, the less responsive they are to variations in tooth movement. The most substantial modifications were identified in cases involving both extraction and palatal expansion, but changes in rugae pattern in cases involving neither extraction nor palatal expansion remain unexplained.

CONCLUSION

If antemortem data are available, the palatal rugae pattern can be utilized to confirm identity, which can be useful in forensic medicine. The stability of the palatal rugae is affected by orthodontic treatment; thus, investigators should be aware of this when evaluating for identification purposes. Third rugae are the most trustworthy and stable sites, and they can be utilized as reference points to analyze tooth movements. The current pilot analysis lays the groundwork for future, prospective studies with larger sample sizes and improved rugae evaluation methodologies. Third rugae are the most trustworthy and stable sites, and they can be utilized as reference points to analyze tooth movements. The current pilot analysis lays the groundwork for future, prospective studies with larger sample sizes and improved rugae evaluation methodologies.

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Conflicts of interest

There are no conflicts of interest.

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