Research Article

ASSESSMENT OF PALATAL RUGAE PATTERNS IN PRE AND POST ORTHODONTIC TREATMENT CASTS

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A B S T R A C T

Objective: To study the palatal rugae patterns of the subjects taking into account, the pre and post orthodontic treatment (extraction cases) dental casts.

Materials and methods: Pre-treatment and post- treatment dental casts of 120 patients (60 males and 60 females) with the age group of above 18 years are studied, to assess the palatal rugae in terms of their number, length and shape or pattern. Measurement of rugae is done with its starting edge at the mid-palatine raphe and length of the rugae is measured based on Lysell's classification,1955. Group comparison was done using independent Student paired test/ Mann-Whitney test at the P < .05 level.

Results: During pre-treatment, the right side of palate had predominantly divergent (41.2 %) followed by wavy (21.2 %) pattern, and left side of palate had predominantly wavy (32.8 %) followed by divergent (26.6 %) pattern. However, on the right side, divergent pattern was more among females (42.8 %) than males (39.7 %). On the left side, wavy pattern was more among males (34.3 %) than females (31.3 %). Males had a higher latero-medial dimension than females on the left side of the palate that was statistically significant (P < .001). It was observed that females had a statistically significant (P < .01) higher antero-posterior palatal dimension and males had a statistically significant (P < .001) higher latero-medial dimension on the left side of the palate. Total samples showed the right side of the antero-posterior dimension had significantly higher scores in both pre-operative (p = .004) and post –operative period (P = .006) respectively. There was no statistically significant differences on the left side of the palate.

Conclusions: Palatal rugae patterns remain constant throughout one's life although there can be dimensional changes seen in them. Divergent pattern is the most predominant of all rugae patterns on the right side in both the genders and wavy pattern is predominant on the left side of the palate. The number of divergent rugae are more in females and the wavy pattern are higher in males. Male population has higher changes in the antero-posterior dimensions between pre and post treatment whereas the latero-medial dimensions are higher in the post-treatment group considering the total samples.

INTRODUCTION

Forensic science has immensely contributed over the years, into the process of human identification. Human identification in post-mortem scenarios is a basic essential and achieving it is one of the challenging task.[1] Identification by visual method is one of the commonest method followed in forensic medicine. However, due to destruction of hard tissues by varied reasons, such as trauma, it becomes difficult and that is when the non-mutilated palatal tissues come to use, as they are well protected by the lips, cheek, tongue, buccal pad of fat and teeth during disasters. Ruga palatine, otherwise called as transverse palatine folds are located in the anterior third of the hard palate of an individual.

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They are formed around 12th to 14th week of intra-uterine life and are claimed to be remaining stable until for the entire lifetime of an individual, till the oral mucosa degenerates after death.[2,3] Palatal rugae aids in swallowing of food, taste perception, speech and suction in children and also helps in the medico legal identification process. The most reliable means of individual identification are through fingerprint analysis, comparative dental analysis and DNA analysis. When compared to these, identification by palatal rugae possess features of an ideal forensic parameter, as it has lifelong stability and post mortem resistance as well.

According to Glossary of Prosthodontics Terms, palatal rugae are anatomical folds or wrinkles; the irregular fibrous connective tissue located in the anterior third of the palate.[4]It was first described by Winslow[5] in the year 1753 and was first illustrated by Santorini[6] in the year 1975. The study of palatal

rugae is termed as palatoscopy or palatal rugoscopy. This was first proposed by a Spanish investigator called Trobo Hermosa, in the year 1932.[7] This method has been used to differentiate between various racial groups, aiding in population identification.[8,9]Lysell in the year 1955, has classified the rugae pattern into primary, secondary and fragmentary rugae.[10] With the benefit of being protected, the use of palatal rugae as forensic aid has added advantages such as low utilization cost, simplicity. There has been studies done in the past to determine sex via this method.

The study intends to know if the palatal rugae patterns remain stable in spite of undergoing extractions as a part of orthodontic treatment in individuals, which therefore would lead us towards considering the palatal rugae pattern as a reliable indicator of human identification in a South Indian population. But if the rugae patterns are found to be having changed patterns post orthodontic treatment, then preserving the post-orthodontic treatment records will be totally essential as it can mislead the investigation, if not. The study also aims at assessing if there is a racial predilection with regard to rugae patterns in individuals.

Aims and Objectives: To study the palatal rugae patterns of the subjects taking into account, the pre and post orthodontic treatment (extraction cases) dental casts.

MATERIALS AND METHODS

Source of data

Pre-treatment and post-treatment dental casts of 120 patients (60 males and 60 females) with the age group of above 18 years are obtained from the dental colleges, in and around Mangalore, from the Department of Orthodontics and Dentofacial Orthopedics.

Ethics statement

This prospective study was approved by the Research Ethics committee of the Institutional Ethics Committee, A J Institute of Medical Sciences & Research Centre.

Inclusion criteria

- Casts with precise details of palatal rugae.
- Casts wherein extraction in the upper arch is considered as an orthodontic treatment plan.

Exclusion criteria

- Presence of dental anomalies.
- Presence of systemic diseases.
- Broken or fractured dental casts.

Method of study

- Pre and post-orthodontic treatment casts of 120 patients (60 males and 60 females) with the age group of above 18 years is obtained.
- Armamentarium required: - Pre and post orthodontic treatment casts.

1. Verniercalipers
2. Magnified lens
3. Lead pencil

Assessment of palatal rugae

- Palatal rugae patterns are studied using magnified lens under adequate daylight.(Figure 1)

- Three parameters are recorded which are as follows: a) Number of rugae b) Size or length of the rugae c) Shape or pattern of the rugae
- Measurement of rugae is done with its starting edge at the mid- palatine raphe.(Figure 2)
- Length of the rugae is measured based on the Lysell's classification (1955), which categorized the rugae into three main categories.
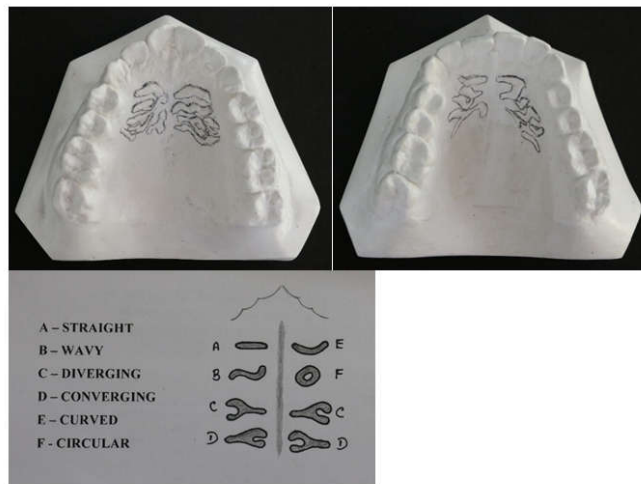
Figure 1 Palatal Rugae patterns

Figure 2 Area of interest to measure the rugae – Mid-palatal raphe

1. Primary – more than 5mm
2. Secondary – 3-5mm
3. Fragmentary- 2- 3mm

- Rugae smaller than 2mm are excluded.
- Rugae patterns are assessed based on the Thomas and Kotze classification (1983) and Kapali *et al* (1997)
- The patterns observed are

1. Straight
2. Curved
3. Wavy
4. Circular
5. Unification (diverging)
6. Unification (converging)
7. Non-specific [one which doesnot fall under any of the above mentioned classes]

Codes of (1-7) are given for the above patterns

Limits of the area of interest (Figure 2)

Area of interest formeasuring the palatal rugae: starts at the mid-palatal raphe and extends till the end of raphe. (ideal scenario)

RESULTS

When the palatal rugae of 120 individuals which comprised of 60 males and 60 females each were assessed, the following results were obtained with the applicable of suitable statistical tests as mentioned below.

Table 1 Descriptive statistics showing gender distribution among study subjects.

Variable	Category	n	%
Gender	Males	60	50.0%
	Females	60	50.0%

Table 2 Gender wise comparison of mean age (in years) among study subjects using Independent Student t Test.

Gender	N	Mean	SD	Min	Max	P-Value
Males	60	21.60	1.90	18	25	0.29
Females	60	21.23	1.90	18	25	

There was no statistically significant difference in the mean age of males and females.

Table 3 Gender wise comparison of Rugae pattern on the right & left sides during Pre treatment period using Chi Square Test.

Sides	Rugae Pattern	Males n	Males %	Females n	Females %	Total n	Total %	χ^2 Value	P-Value
Right	Curved	34	19.0%	21	11.7%	55	15.3%	8.149	0.15
	Convergent	17	9.5%	15	8.3%	32	8.9%		
	Divergent	71	39.7%	77	42.8%	148	41.2%		
	Non-specific	2	1.1%	6	3.3%	8	2.2%		
	Straight	15	8.4%	25	13.9%	40	11.1%		
	Wavy	40	22.3%	36	20.0%	76	21.2%		
	Total	179	49.9%	180	50.1%	359	100.0%		
Left	Curved	32	18.0%	39	21.8%	71	19.9%	6.401	0.38
	Convergent	6	3.4%	11	6.1%	17	4.8%		
	Divergent	48	27.0%	47	26.3%	95	26.6%		
	Non-specific	2	1.1%	0	0.0%	2	0.6%		
	Straight	27	15.2%	26	14.5%	53	14.8%		
	Wavy	61	34.3%	56	31.3%	117	32.8%		
	Circular	2	1.1%	0	0.0%	2	0.6%		
	Total	178	49.9%	179	50.1%	357	100.0%		

Among 120 subjects (60 males & 60 females), a total of 359 rugae were present.

Though statistically not significant, it was observed that the right side of palate had predominantly divergent (41.2 %) followed by wavy (21.2 %) rugae pattern, and left side of palate had predominantly wavy (32.8 %) followed by divergent (26.6 %) rugae pattern. This pattern also extended to both the gender on the right and left of the palate. However, on the right side, divergent rugae pattern was more among females (42.8 %) than males (39.7 %). On the left side, wavy rugae pattern was more among males (34.3 %) than females (31.3 %).

Table 4 Gender wise comparison of mean dimensions of palatal rugae on the right and left sides during Pre-operative period using Mann Whitney Test.

Sides	Parameters	Gender	N=359	Mean	SD	Mean Diff	P-Value
Right	Antero- Posterior	Males	179	4.43	2.55	-0.52	0.07
		Females	180	4.95	2.94		
	Latero- Medial	Males	179	10.83	2.74	0.27	0.45
		Females	180	10.56	2.65		
Left	Antero- Posterior	Males	178	3.97	2.48	-0.01	0.07
		Females	179	3.98	1.84		
	Latero- Medial	Males	178	11.69	2.80	1.38	<0.001*
		Females	179	10.31	2.29		

It was observed that males had a higher latero-medial dimension than females on the left side of the palate that was

statistically significant (P < .001). There was no significant difference in the mean dimension for other parameters.

Table 5 Gender wise comparison of Rugae pattern on the right & left sides during Post treatment period using Chi Square Test.

Sides	Rugae Pattern	Males n	Males %	Females n	Females %	Total n	Total %	χ^2 Value	P-Value
Right	Curved	34	19.0%	23	12.8%	57	15.9%	6.587	0.25
	Convergent	17	9.5%	15	8.3%	32	8.9%		
	Divergent	70	39.1%	77	42.8%	147	40.9%		
	Non-specific	2	1.1%	6	3.3%	8	2.2%		
	Straight	15	8.4%	23	12.8%	38	10.6%		
	Wavy	41	22.9%	36	20.0%	77	21.4%		
	Total	179	49.9%	180	50.1%	359	100.0%		
Left	Curved	32	18.0%	41	22.9%	73	20.4%	7.033	0.32
	Convergent	6	3.4%	11	6.1%	17	4.8%		
	Divergent	48	27.0%	47	26.3%	95	26.6%		
	Non-specific	2	1.1%	0	0.0%	2	0.6%		
	Straight	27	15.2%	26	14.5%	53	14.8%		
	Wavy	61	34.3%	54	30.2%	115	32.2%		
	Circular	2	1.1%	0	0.0%	2	0.6%		
	Total	178	49.9%	179	50.1%	357	100.0%		

Though statistically not significant, it was observed that the right side of palate had predominantly divergent (40.9 %) followed by wavy (21.4 %) rugae pattern, and left side of palate had predominantly wavy (32.2 %) followed by divergent (26.6 %) rugae pattern. This pattern also extended to both the gender on the right and left of the palate. However, on the right side, divergent rugae pattern was more among females (42.8 %) than males (39.1 %). On the left side, wavy rugae pattern was more among males (34.3 %) than females (30.2 %).

Table 6 Gender wise comparison of mean dimensions of palatal rugae on the right & left sides during Post-operative period using Mann Whitney Test.

Sides	Parameters	Gender	N=359	Mean	SD	Mean Diff	P-Value
Right	Antero- Posterior	Males	179	4.47	2.44	-0.32	0.30
		Females	180	4.79	2.71		
	Latero- Medial	Males	179	11.12	2.86	0.48	0.08
		Females	180	10.63	2.68		
Left	Antero- Posterior	Males	178	3.96	2.68	-0.34	0.01*
		Females	179	4.29	2.32		
	Latero- Medial	Males	178	11.47	3.29	1.37	<0.001*
		Females	179	10.10	2.81		

It was observed that females had a statistically significant (P < .01) higher antero-posterior palatal dimension and males had a statistically significant (P < .001) higher LM dimension on the left side of the palate. The mean dimensions on the right side were not significant.

Table 7 Comparison of Rugae pattern on the right & left sides between Pre & Post treatment period among Males using Marginal Homogeneity Test.

Sides	Rugae Pattern	Pre-op n	Pre-op %	Post-op n	Post-op %	MH Value	P-Value
Right	Curved	34	19.0%	34	19.0%	8.500	0.47
	Convergent	17	9.5%	17	9.5%		
	Divergent	71	39.7%	70	39.1%		
	Non-specific	2	1.1%	2	1.1%		
	Straight	15	8.4%	15	8.4%		
	Wavy	40	22.3%	41	22.9%		
	Total	179	100.0%	179	100.0%		
Left	Curved	32	18.0%	32	18.0%	0.000	1.00
	Convergent	6	3.4%	6	3.4%		
	Divergent	48	27.0%	48	27.0%		

Comparison of Rugae pattern on the right & left sides between Pre & Post treatment period among Males using Marginal Homogeneity Test

		Pre-op		Post-op	
Non-specific		2	1.1%	2	1.1%
Straight		27	15.2%	27	15.2%
Wavy		61	34.3%	61	34.3%
Circular		2	1.1%	2	1.1%
Total		178	100.0%	178	100.0%

There was no statistically significant difference between pre and post treatment period among males on either side of the palate.

Table 8 Comparison of Rugae pattern on the right & left sides between Pre & Post treatment period among Females using Marginal Homogeneity Test.

Sides	Rugae Pattern	Pre-op		Post-op		MH Value	P-Value
		n	%	n	%		
Right	Curved	21	11.7%	23	12.8%		
	Convergent	15	8.3%	15	8.3%		
	Divergent	77	42.8%	77	42.8%		
	Non-specific	6	3.3%	6	3.3%	6.000	0.16
	Straight	25	13.9%	23	12.8%		
	Wavy	36	20.0%	36	20.0%		
	Total	180	100.0%	180	100.0%		
Left	Curved	39	21.8%	41	22.9%		
	Convergent	11	6.1%	11	6.1%		
	Divergent	47	26.3%	47	26.3%		
	Non-specific	0	0.0%	0	0.0%	7.000	0.16
	Straight	26	14.5%	26	14.5%		
	Wavy	56	31.3%	54	30.2%		
	Circular	0	0.0%	0	0.0%		
	Total	179	100.0%	179	100.0%		

There was no statistically significant difference between pre and post treatment period among males on either side of the palate.

Table 9 Comparison of Rugae pattern on the right & left sides between Pre & Post treatment period in total Samples using Marginal Homogeneity Test.

Sides	Rugae Pattern	Pre-op		Post-op		MH Value	P-Value
		n	%	n	%		
Right	Curved	55	15.3%	57	15.9%		
	Convergent	32	8.9%	32	8.9%		
	Divergent	148	41.2%	147	40.9%		
	Non-specific	8	2.2%	8	2.2%	14.500	0.48
	Straight	40	11.1%	38	10.6%		
	Wavy	76	21.2%	77	21.4%		
	Total	359	100.0%	359	100.0%		
Left	Curved	71	19.9%	73	20.4%		
	Convergent	17	4.8%	17	4.8%		
	Divergent	95	26.6%	95	26.6%		
	Non-specific	2	0.6%	2	0.6%	7.000	0.16
	Straight	53	14.8%	53	14.8%		
	Wavy	117	32.8%	115	32.2%		
	Circular	2	0.6%	2	0.6%		
	Total	357	100.0%	357	100.0%		

There was no statistically significant difference between pre and post treatment period in total samples.

Table 10 Comparison of mean dimensions of Palatal Rugae b/w Right & Left sides during Pre & Post-operative Period among males using Wilcoxon Signed Rank Test.

Time	Parameters	Sides	N	Mean	SD	Mean Diff	P-Value
Pre-op	Antero- Posterior	Right	178	4.43	2.55	0.46	0.22
		Left	178	3.97	2.48		
	Latero- Medial	Right	178	10.85	2.74	-0.84	<0.001*
		Left	178	11.69	2.80		
Post-op	Antero- Posterior	Right	178	4.47	2.45	0.51	0.02*
		Left	178	3.96	2.68		
	Latero- Medial	Right	178	11.12	2.87	-0.35	0.04*
		Left	178	11.47	3.29		

Pre-operatively, the LM dimension was more on the left side that was statistically significant (P < .001). Post-operatively, the AP dimension was more on the right side (P = .02) and LM

was more on the left side (P = .04) which was statistically significant.

Table 10 Comparison of mean dimensions of Palatal Rugae b/w Right & Left sides during Pre & Post-op Period among Females using Wilcoxon Signed Rank Test.

Time	Parameters	Sides	N	Mean	SD	Mean Diff	P-Value
Pre-op	Antero- Posterior	Right	179	4.95	2.94	0.97	0.002*
		Left	179	3.98	1.84		
	Latero- Medial	Right	179	10.58	2.64	0.27	0.04*
		Left	179	10.31	2.29		
Post-op	Antero- Posterior	Right	179	4.79	2.72	0.50	0.13
		Left	179	4.29	2.32		
	Latero- Medial	Right	179	10.63	2.69	0.53	0.08
		Left	179	10.10	2.81		

Pre-operatively, right side of both antero-posterior (P = .002) and latero-medial (P = .04) dimension had higher score than the left side that was statistically significant.

Table 11 Comparison of mean dimensions of Palatal Rugae b/w Right & Left sides during Pre & Post-op Period among total samples using Wilcoxon Signed Rank Test.

Time	Parameters	Sides	N	Mean	SD	Mean Diff	P-Value
Pre-op	Antero- Posterior	Right	357	4.69	2.76	0.72	0.004*
		Left	357	3.98	2.18		
	Latero- Medial	Right	357	10.72	2.69	-0.28	0.17
		Left	357	11.00	2.64		
Post-op	Antero- Posterior	Right	357	4.63	2.59	0.50	0.006*
		Left	357	4.13	2.51		
	Latero- Medial	Right	357	10.87	2.79	0.09	0.98
		Left	357	10.78	3.13		

Table 12 Comparison of mean dimensions of palatal rugae between right and left sides during pre and post-operative period among Males using Wilcoxon Signed Rank Test.

Sides	Parameters	Time	N	Mean	SD	Mean Diff	P-Value
Right	Antero- Posterior	Pre-op	179	4.43	2.55	-0.04	0.84
		Post-op	179	4.47	2.44		
	Latero- Medial	Pre-op	179	10.83	2.74	-0.29	<0.001*
		Post-op	179	11.12	2.86		
Left	Antero- Posterior	Pre-op	178	3.97	2.48	0.01	0.93
		Post-op	178	3.96	2.68		
	Latero- Medial	Pre-op	178	11.69	2.80	0.22	0.29
		Post-op	178	11.47	3.29		

There was a statistically significant difference at the antero-posterior dimension between the pre and post-operative period on the right side of the palate (P = .001).

Table 12.1 Comparison of mean dimensions of palatal rugae between right and left sides during pre and post-operative period among females using Wilcoxon Signed Rank Test.

Sides	Parameters	Time	N	Mean	SD	Mean Diff	P-Value
Right	Antero- Posterior	Pre-op	180	4.95	2.94	0.16	0.41
		Post-op	180	4.79	2.71		
	Latero- Medial	Pre-op	180	10.56	2.65	-0.07	0.97
		Post-op	180	10.63	2.68		
Left	Antero- Posterior	Pre-op	179	3.98	1.84	-0.31	0.59
		Post-op	179	4.29	2.32		
	Latero- Medial	Pre-op	179	10.31	2.29	0.21	0.89
		Post-op	179	10.10	2.81		

There was no statistically significant difference between the mean dimensions of palatal rugae between pre and post-operative period on right and left side among females

Table 13 Comparison of mean dimensions of Palatal Rugae b/w Pre & Post-op Period on right & left sides among total samples using Wilcoxon Signed Rank Test.

Sides	Parameters	Time	N	Mean	SD	Mean Diff	P-Value
Right	Antero- Posterior	Pre-op	359	4.69	2.76	0.06	0.30
		Post-op	359	4.63	2.58		
	Latero- Medial	Pre-op	359	10.70	2.70	-0.18	0.003*
		Post-op	359	10.87	2.78		
Left	Antero- Posterior	Pre-op	357	3.98	2.18	-0.15	0.85
		Post-op	357	4.13	2.51		
	Latero- Medial	Pre-op	357	11.00	2.64	0.21	0.41
		Post-op	357	10.78	3.13		

The right latero-medial dimensions had significantly higher scores in post-operative period (P = .003). There was no statistically significant differences on the left side of the palate. The right side of the antero-posterior dimension had significantly higher scores In both pre-operative (p = .004) and post –operative period (P = .006) respectively.

There was a statistically significant difference at the antero-posterior dimension between the pre and post-operative period on the right side of the palate (P = .001).

DISCUSSION

Palatal rugoscopy has been found to be the simplest, yet one of the reliable means of individual identification. Various studies have been conducted to assess the stability of rugae. Many studies have concluded the uniqueness of the palatal rugae. One of the study conducted by Bailey *et al*,[11] reported that the medial and lateral parts of the third rugae appeared to be more stable when compared to the first and second rugae. Studies also revealed sexual dimorphism in the rugae patterns. This has been similar to the results obtained in the current study wherein there is a difference in predominency of various rugae patterns in males and females which is divergent pattern observed in a higher percentage among females on the right side with 42.8 % pre and post-operatively. However male population showed a higher number of wavy pattern on the left side with 34.3 % pre and post-treatment.

But a study conducted by Purohit *et al*,[12] concluded that the count of rugae was higher on right than on the left. Both the genders showed predominance in wavy type. The mean number of rugae was found to be more in females than males but the difference was statistically insignificant. In the current study which consisted of 120 samples, a total of 359 rugae were detected on the right side and 357 rugae were detected on the left side of the palate.

According to Balgi *et al*,[13] The average length of rugae was greater in males than in females. The average number of rugae were same in both males and females. Straight pattern was commonly seen in females than in males. A study conducted on burn victims and cadavers to determine the extent of preservation of palatal rugae, conclude that 93% of burn victims and 77% of human cadavers have grade 0 changes (normal) and these changes were less pronounced than the body changes which had occurred due to burns again proving the stability of palatal rugae unaffected at even worst circumstances.[14]

There is no statistically significant differences found on the left side of the palate in any of the parameters when compared except for the higher percentage of wavy rugae pattern (34.3%) which was observed among the male population when compared to the females who showed a lower value of 31.3% pre-operatively and 30.2% post-operatively.

The antero-posterior rugae dimensions were higher in females with a p-value of < 0.01 and the latero-medial dimensions were higher in male population with a p-value of < 0.001.

The antero-posterior dimension of the rugae which were present on the right side had significantly higher scores in both pre-operative (p = .004) and post –operative period (P = .006) respectively. There was also a statistically significant difference in the antero-posterior dimension between the pre and post treatment study casts rugae on the right side of the palate (P = .001).

Hence considering the obtained results, the method of palatal rugoscopy is definitely to be considered as a method of personal identification considering the uniqueness as well as the the predominency of different rugae pattern among the genders which hence goes by the study concluded by Caldas *et al*[15] wherein establishing identity was supported with palatoscopy method.

CONCLUSIONS

This study concluded that:

1. The palatal rugae patterns remain constant throughout one's life although there can be dimensional changes seen in them.
2. Divergent rugae pattern is the most predominant of all rugae patterns on the right side in both the genders and wavy pattern is predominant on the left side of the palate.
3. No much changes occurred from pre to post treatment on the left side of the palate whereas there are significant changes seen on the right side.
4. The number of divergent rugae are more in females and the wavy pattern are higher in males.
5. Male population has higher changes in the antero-posterior dimensions between pre and post treatment whereas the latero-medial dimensions are higher in the post-treatment group considering the total samples.

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