



# Assessment of Reliability of Rugoscopy for Identification of Gender

Sara Gardezi<sup>1</sup>

BDS

Nuzhat Hassan<sup>2</sup>

M.Phil

Sarwat Memon<sup>3</sup>

BDS, FCPS

**OBJECTIVE:** To assess rugoscopy for identification of gender in a subset of Karachi population Study design: A Cross sectional Comparative study Place and duration: Dental O.P.D of Ziauddin Hospital Clifton, Karachi from July 2016 -2017.

**METHODOLOGY:** A sample size of 456 individuals aged between 15 and 55 years fulfilling inclusion and exclusion criteria were recruited for the study. The shapes and size of rugae were evaluated on dental casts by classification given by the Kapali et al and Thomas et al respectively. Chi-square test was used to see gender dimorphism in rugae shapes and Mann Whitney U test was used for gender dimorphism in rugae size. A p-value of  $\leq 0.05$  was considered significant. The equation given by Bharath et al. was used to determine gender of an individual.

**RESULTS:** A significant gender dimorphism in rugae shape among Karachi population was observed. The most common rugae shape in males was found to be wavy followed by straight, curved, convergent, divergent and circular rugae. However, the most common rugae shape among females was found to be curved followed by wavy, straight, divergent, convergent and circular rugae. On observing the size of rugae significant gender dimorphism was reported for secondary rugae (p-value= 0.045). The overall percentage of gender prediction by rugoscopy was 45.6 %.

**CONCLUSION:** Rugoscopy have potential for gender identification and thus may be used for gender identification as an ancillary and supplemental tool in forensic investigation.

**KEY WORDS:** Rugoscopy, Gender Identification, Forensic identification

**HOW TO CITE:** Gardezi S, Hassan N, Memon S. Assessment of reliability of rugoscopy for identification of gender. J Pak Dent Assoc 2019;28(3):113-117.

**DOI:** <https://doi.org/10.25301/JPDA.283.113>

**Received:** 14 November 2018, **Accepted:** 22 April 2019

## INTRODUCTION

Rugae is a term used in anatomy which refers to a series of ridges that are produced by folding of the wall of an organ. Palatal rugae (PR) are anatomical folds of the oral mucosa present on the anterior third of the palate on each side of the median palatal raphe behind the incisive papillae. Their number, shape, size and location vary on both left and right side of the hard palate and also vary from person to person.<sup>1</sup> Study of different patterns of the palatal rugae is called Rugoscopy.<sup>2</sup> Palatal rugae pattern due to post-mortem resistance, individuality, stability, and also low cost marks it ideal for gender identification.<sup>2-7</sup>

Forensic analysts have used various methods like bite marks registration, radiographic analysis, photographs, DNA analysis, Cheiloscopy and Rugoscopy for gender identification.<sup>2,3</sup> Literature survey revealed that various

authors have reported that in certain forensic circumstances there are limitations to identification of the deceased by fingerprints, visual identification, DNA probing and dental records.<sup>6-10</sup> Many studies support the stability of palatal rugae and suggested that there might be some change in their size due to growth of the palate but their shape remains unaffected.<sup>6,7</sup> They have been linked with fingerprints because of their stability throughout life and also their potential to regenerate after destruction with exactly the same pattern as before. Literature review reveals rugae variability in different ethnic and population groups.<sup>8-16</sup> Gardezi S, Hassan N, Memon S and Mughal A in their study found significant difference in rugae pattern amongst five ethnicities of Pakistan.<sup>16</sup> Studies conducted by Babaji P et al<sup>13</sup>, Chopra A et al<sup>14</sup> and Subramanian PR et al<sup>15</sup> in their studies used Rugoscopy for gender identification. Different methods are reported in literature for recording the rugae and size pattern.<sup>12,16,17</sup> In the present study tracing of maxillary cast were used due to low cost, simplicity, and reliability.

Acts of terrorism in Pakistan have increased significantly

1. MPhil Trainee, Department of Oral Biology, Ziauddin University.

2. Professor, Department of Anatomy, Ziauddin University.

3. Assistant Professor, Department of Orthodontics, Ziauddin University.

Corresponding author: "Dr. Sarwat Memon" <[sarwatmaqsood@yahoo.com](mailto:sarwatmaqsood@yahoo.com)>

in recent years. Therefore, the Palatal rugae pattern of an individual because of its individuality, postmortem resistance, and stability may be considered as a useful alternative source for gender determination. To the best of our knowledge we were unable to find similar study locally. Our objective was therefore, to assess Rugoscopy for identification of gender in a subset of Karachi population.

## METHODOLOGY

This cross sectional comparative study was conducted at Out Patient Orthodontic Departments of Ziauddin Hospital Karachi from July 2016 to 2017. A written informed consent was obtained from all subjects after explaining the objectives and rationale of the study. We used convenience sampling technique for inclusion of subjects. Pakistani subjects with age groups between 15 to 55 years with complete dentition and good oral hygiene were included in this study. Subjects with a prior history of orthodontic or prosthodontic treatment, severe palatal trauma and congenital syndromes affecting the palate or any surgical procedures performed on the hard palate were excluded from our study. Sample size for this study was calculated by WHO sample size estimation calculator. A sample size of 456 gave the power of > 80%. The study was conducted after the approval from ERC and BASR of Ziauddin University. All the information gathered during the study was kept confidential.

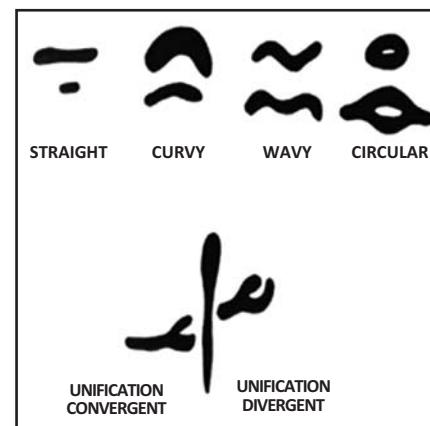
Impression of the subject was taken using impression material (Irreversible hydrocollide alginate, Kromopan) in a plastic perforated tray. The impression was disinfected with 0.5% hypochlorite for 10 minutes. High strength plaster (ISI Kopo-hard CKH-52 Dental plaster, 0.30 water/powder ratio) was poured in the impression on dental vibrator to avoid air bubbles. The impression was separated from the cast within 30 minutes as it is sufficient time for initial setting. Any portion of the cast that interfered with separation from the tray was trimmed away with the Bard parker knife. The impression was trimmed if required and the base was made with dental plaster using orthodontic base former with 22mm of base/cast height. The cast was assigned with patient number. Rugae shape and length was traced using graphite pencil and was analyzed under adequate light and magnification. The palatal rugae were delineated using 0.5 mm HB pencil under adequate light (Figure 1). Shapes of rugae on palate were recorded as per classification given by Kapali et al. who described the following rugae patterns (Figure 2).<sup>18</sup>

Size of each rugae was measured from one end to the other end by using a pointed divider as per classification given by Thomas et al<sup>19</sup> in 1983 as shown in table 1 and figure 3.

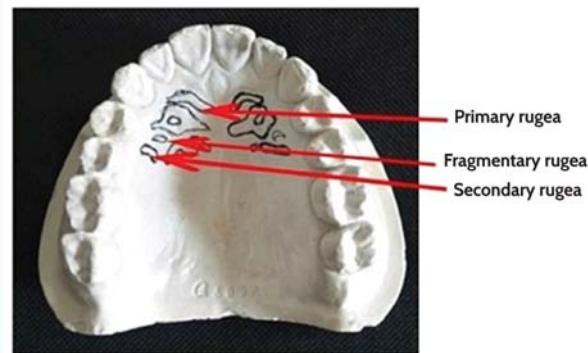


The gender of the individual was determined as per the

**Figure 1:** Showing the different steps of Rugoscopy from the current study



**Figure 2:** Diagrammatic representation of different types of rugae pattern



**Figure 3:** Diagrammatic representation of different sizes of rugae current study as per classification given by Thomas et al

descriptions/equation given by Bharath et al<sup>20</sup>, in 2011.  $\text{Gender} = -0.2620(\text{Primaryrugae}) - 0.5133(\text{Secondaryrugae}) - 0.6614(\text{Fragmentaryrugae}) + 0.3366(\text{Straight}) + 0.4582(\text{Wavy}) + 0.4353(\text{curved}) + 0.5096(\text{Circular})$ .

After executing our data in the above equation the gender of the individual was determined with the help of canonical centroids of -0.3088 to 0.3088. If the product obtained was close to 0.3088, then the proposed gender was male. But if

the product obtained was close to -0.3088 then the proposed gender was female.

The collected data was analyzed on SPSS version 20(Armonk, New York, U.S.A). All quantitative variables were presented as the mean and standard deviation and all qualitative variables were presented as the percentage and frequencies. Chi-square test was used for association gender dimorphism in rugae shapes and Mann Whitney U test was used for gender dimorphism in rugae size. Level of significance was set at p-value of  $\leq 0.05$ .

## RESULTS

Out of 456 participants who underwent this study 203(44.5%) were females and 253(55.5%) were males. Chi-Square test was applied to see the gender dimorphism in rugae shape. The most common rugae shape in males was found to be wavy followed by straight, curved, convergent, divergent and circular rugae. However, the most common rugae shape among females was found to be curved followed by wavy, straight, divergent, convergent and circular rugae. A significant gender dimorphism was observed (p-value < 0.05) as depicted in Table 2.

Our data was not following normality assumptions, so Kolmogorov-Smirnov test was run over the data therefore instead of independent sample T test; Mann Whitney U test was used to see the gender dimorphism in rugae length. The secondary rugae were more prevalent as compared to primary and fragmentary rugae in male and female both. However, significant gender dimorphism was reported for secondary rugae (p- value= 0.045) (Table 3)

Out of 456 participants who underwent the study 28.1% of males and 32.5% of females were correctly identified. The overall percentage of gender prediction by Rugoscopy was 45.6% as shown in Table 4.

## DISCUSSION

Rugae patterns are unique in their morphology. They are considered to be analogous to fingerprints.<sup>16</sup> Pakistan because of its strategic geographical location and sharing border with various countries has a monumental influx of immigrants. Karachi is a cosmopolitan city of Pakistan with multiple ethnic groups. Therefore, Karachi is a special entity which is needed to be explored.

Several researchers have reported racial and gender differences in palatal rugae shape and size which may help to identify the population especially in disaster victims.<sup>17-22</sup> The present study evaluated 253 males and 203 females aged 15 to 55 years for gender dimorphism in rugae shapes and length. A statistically significant gender

dimorphism was found for rugae shape and length. In our study wavy rugae type predominated in males followed by curved, convergent, divergent and circular while curved pattern dominated in females followed by wavy, straight, divergent, convergent, and circular. (p-value=0.05) Many authors in the recent years have demonstrated significant relationship between rugae shape and gender.<sup>22-24</sup> Amjad et al<sup>21</sup> and Babu et al<sup>22</sup> in their researches found significant gender dimorphism in rugae shape. In our present study, males had more wavy palatal rugae while females had more curved-shaped rugae pattern. Circular rugae were rarely seen in both genders. Kepali et al<sup>18</sup> and Venegas et al<sup>23</sup> in their studies also reported similar rugae pattern in males. Azab et al<sup>24</sup> in Egyptian population observed that males had converging rugae pattern and females had more curved rugae pattern. Fahmi et al<sup>25</sup> reported that Saudi females converging rugae type while males had a significantly greater number of circular rugae shape. In contrast to our study Shetty et al<sup>26</sup> reported curved rugae pattern in Indian than Tibetan males while Tibetan females had predominant wavy rugae patterns than Indian females. Other studies have reported no significant gender dimorphism between rugae patterns. Bajracharya et al<sup>27</sup> found no statistically significant gender dimorphism in Nepalese subjects.

In our study secondary rugae was more predominant followed by primary and fragmentary rugae type. Furthermore, significant gender dimorphism was observed for secondary rugae.(p- value=0.045). However, Azab et al<sup>24</sup> in Egyptian population, Fahmi et al<sup>25</sup> in Saudi population and Selvamani et al<sup>28</sup> in Indian population reported primary rugae to the prevalent then secondary rugae. Surekha et al<sup>29</sup> found in their study primary rugae to be more common in Kerala population, whereas secondary rugae were more common in Manipuri population.

On discriminate analysis of size and shape of palatal rugae, an equation proposed by Bharath et al<sup>20</sup> was used. Bharath et al<sup>19</sup> in Indian population found the percentage of gender prediction to be 78% accurate. On the contrary, when the discriminate analysis of size and shape of palatal rugae developed by Bharath et al<sup>19</sup> was applied to our sample, the percentage of gender prediction correctly was found to be only 45.6%. Saadeh et al<sup>30</sup> in their multivariate analysis combined, four linear and one angular rugae measurements and correctly predicted gender in 71.4 % of the sample. Ahmed AA and Hamid A<sup>31</sup> using logistic regression analysis in the Sudanese Arabs reported gender predictive value of 60% using dimensions and orientations and predictive value of 58% using shapes alone. Saraf A et al<sup>32</sup> in their study used logistic regression analysis and correctly predicted gender in 99.2% of their sample using rugae shapes only. This suggests that to improve the accuracy of gender

prediction, a new standard gender prediction equation using logistic regression analysis should be developed for our population.

It was single-center study hence the results cannot be generalized for the Karachi population. We recommend that multicenter prospective nationwide studies including different ethnicities to further strengthen and validate results of our study. In addition, a data bank of palatal rugae can be established as they may serve as an ante- mortem record. To improve the accuracy for gender identification, a new standard gender prediction equation should be developed by using advance statistical method for our population.

## CONCLUSIONS

Rugoscopy have potential for gender identification and thus can be used for gender identification as an ancillary and supplemental tool in forensic investigation.

## CONFLICT OF INTEREST

None declared

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