Original Article

Comparative Reliability of Cheiloscopy and Palatoscopy in Identification and Gender Determination among 5–14-Year-Old Children: An *In vivo* Study

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A B S T R A C T

Background and Aim: The study of lip prints and palatal rugae patterns is considered to be distinct to every individual and consequently holds the potential for identification. Thus, the aim of this study is to ascertain the use of lip prints and palatal rugae pattern in identification and gender determination among 5–14-year-old children.
Methods: A total of 92 children, 46 males and 46 females, were selected from the Outpatient Department of Pedodontics and Preventive Dentistry, Yenepoya Dental College, Mangalore. Thomas and Kotze classification were used to analyze the dental casts to study palatal rugae patterns. Suzuki and Tsuchihashi classification was used to analyze lip prints recorded using butter paper.
Statistical Analysis Used: Independent *t*-test was used for estimating the total number of rugae and number of primary rugae. Chi-square test was used for determining the predominant shape, direction, and unification in palatal rugae and for the association of lip prints with gender determination in all the quadrants.
Results: Type 1, 1', and 2 were observed in females more, whereas Type 3 and 4 were observed in males. The predominant shape of the rugae was wavy and curved among males and females. The incidence of forwardly directed and backwardly directed rugae was more in males and perpendicularly directed rugae were more in females.
Conclusions: The present study proves that both cheiloscopy and palatoscopy have the potential to identify an individual; however, lip prints are said to be more reliable in identifying the sex of an individual as compared to palatal rugae patterns.

KEY WORDS: *Cheiloscopy, forensic odontology, gender differentiation, identification, palatoscopy*

INTRODUCTION

One of the most demanding trials that man has been confronted with is human identification. Human identification is based on scientific principles, chiefly involving dental records, fingerprints, and DNA comparisons. Sometimes, it becomes a necessity to apply supplementary and uncommon techniques such as cheiloscopy and palatoscopy.[1] Cheiloscopy (derived from the Greek word cheilos which means lips) is an investigative technique in forensics which deals with the identification of humans based on lip traces.[2] It studies the furrows or grooves which is present on the vermilion border or red part of human lips. Cheiloscopy is considered important as there is a proven fact that lip prints are unique to each individual, except in monozygotic twins.[3]

Lip prints are identifiable at the 6th week of intrauterine life, and succeeding that, their pattern rarely changes and resists many afflictions such as herpetic lesions. Lip prints can be acquired directly from a body or indirectly at a crime scene from discrete sources such as cigarette butts, clothes, cups, letters, windows, and doors.[3] Lip prints are said to be permanent and unchangeable. They serve as indispensable evidence left at crime scenes.[4] In 1902, the biologic phenomenon of characteristic patterns of furrows on the vermilion border of human lips was elucidated by Fischer. Considerable research has been carried out by two Japanese scientists, Tsuchihashi and Suzuki in this field thenceforth. The classification of lip prints was proposed by them which is widely used in literature till date.[3]

Palatal rugea refers to the ridges present on the anterior part of the palatal mucosa and on each side of the median palatal raphe and behind the incisive papilla.[5] The study

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of palatal rugae in order to establish a person's identity is called palatoscopy. The palatal rugae, similar to fingerprints, are protected from high temperatures, trauma, disease, or chemical attack due to its internal position in the oral cavity and also protected by the lips, cheeks, tongue, teeth and bone, and prosthetic devices.[6] At birth, the palatine rugae are well formed, and the pattern of orientation is said to be typical for each person.[7] Once they are formed, only change in length is observed which is due to normal growth otherwise, they stay in the same position throughout the lifespan of a person.

When acts of terrorism or mass disasters, traffic accidents, occur in which it is not easy to identify a person according to their fingerprints or dental records, palatine rugae can be considered as an alternative method of identification. The palatine rugae are permanent and unique to each person and help in establishing identity through discrimination (through casts, tracings, or digitized rugae pattern).[5] Pediatric dentists can implement their expertise in recognition of signs and symptoms of child abuse and identification of such victims, thereby helping the legal officers in their investigations. Proper recording of dental findings is also an important step in the management of dental records. Dental records of pediatric patients should be retained until the patient reaches the age of maturity.[7]

There are not many studies available in literature which compares these two techniques, especially in children. Hence, the objectives of this study were (i) to assess the morphology of palatal rugae and lip prints among 5–14-year-old children, (ii) to assess the association between gender and different palatal rugae and lip print patterns, and (iii) to compare the accuracy of cheiloscopy and palatoscopy in identification and gender determination.

METHODS

The present cross-sectional study was conducted in the Department of Pedodontics and Preventive Dentistry after obtaining approval from the Institutional Ethical Committee. All the participants and their parents were informed priorly about the purpose and objective of the study and a signed informed consent form was obtained from all. A total of 92 healthy children (46 males and 46 females) of age ranging between 5 and 14 years who visited as outpatients in Yenepoya Dental College were randomly selected for the study.[8]

Children with malformation, deformity, scars, and active lesions on the lips, with congenital abnormalities, bony and soft-tissue protuberances, lesions, scars, trauma to the palate, and those undergoing interceptive orthodontic procedures were excluded from the study. After obtaining informed consent, the lip print of each individual was recorded. The lipstick was applied with the brush in a single motion evenly on the lips of each individual.[2]

The children were asked to retain a relaxed lip position, and a lip impression was taken using a butter paper. Minimal pressure was maintained while making the lip impression. The butter paper consisting of the lip print was then stuck on to a bond paper with the help of a cellophane tape. The impression was subsequently visualized with a magnifying lens [Figure 1].

The lip prints were divided into four quadrants; right upper as the first quadrant, left upper as the second quadrant, left lower as the third quadrant, and right lower as the fourth quadrant in accordance with Venkatesh and David. The lip print patterns were analyzed following the classification of Suzuki and Tsuchihashi.[2] The number of lines and furrows present, their length, branching and combinations were noted. The lip prints obtained were coded, while noting the name and sex of the respective individuals [Figure 2]. At the time of analysis, the sex of the print was not disclosed.[1] In this study, we followed the classification of patterns of the lines on the lips proposed by Tsuchihashi.[9]

- Type 1: Clear-cut vertical grooves that run across the entire lips
- Type 1′: Similar to type 1, but do not cover the entire lip
- Type 2: Branched grooves
- Type 3: Intersected grooves
- Type 4: Reticular grooves
- Type 5: Grooves do not fall into any of the type 1–4 and cannot be differentiated morphologically (undetermined).

The sex of the individual was determined as per the descriptions given by Vahanwala *et al*.[10,11]
- Type 1, 1′: Pattern dominant - female
- Type 2: Patterns are dominant - female
- Type 3: Pattern present - male
- Type 4: Male
- Type 5: (varied patterns) – male.

Same patterns in all quadrants – female

Different patterns in all quadrants suggest male sex and same patterns in all quadrants suggest female sex.[8] All the lip prints of the 92 children were numbered with a unique code and were examined without disclosing the subject's identity for sex determination. The results obtained were verified from the coded data collected at the beginning of the study.[1]

Alginate impressions of maxillary arches were made using appropriate perforated metal trays and the casts were prepared using dental stone devoid of air bubbles, especially in the anterior third of the palate. The individual palatal rugae were then delineated using a sharp graphite pencil on dental casts under adequate light.[12] Interpretation of the rugae pattern in the casts was analyzed with the help of magnifying lens in accordance with the Thomas and Kotze classification[13] [Figure 3].

The parameters assessed were:
1. Total number of rugae
2. Number of primary rugae
3. Predominant shape
4. Predominant direction
5. Unification of rugae.

The rugae were classified based on their length as:
1. Primary - >5 mm
2. Secondary - 3–5 mm
3. Fragmentary - <3 mm.

Rugae <2 mm were disregarded. A ruga's length was determined by measuring its greatest dimension regardless of its shape.

The rugae were divided into four types based on their shape as:

1. Curved: They had a crescent shape and curved gently [Figure 4]
2. Wavy: If there was a slight curve at the origin or termination of a curved rugae [Figure 5]
3. Straight: They run directly from their origin to termination
4. Circular: Rugae that form a definite continuous ring were classified as circular.

The direction of the rugae was determined by measuring the angle formed by the line joining its origin and termination and the line perpendicular to the median raphe. Based on the direction, rugae were classified as:

1. Forwardly directed rugae – associated with positive angles [Figure 6]
2. Backwardly directed rugae – associated with negative angles [Figure 7]
3. Perpendicular rugae – associated with zero angles [Figure 8].

Unification was said to have occurred when two rugae joined at their origin or termination:

1. Diverging - If two rugae had the same origin from the midline but immediately branched [Figure 9]
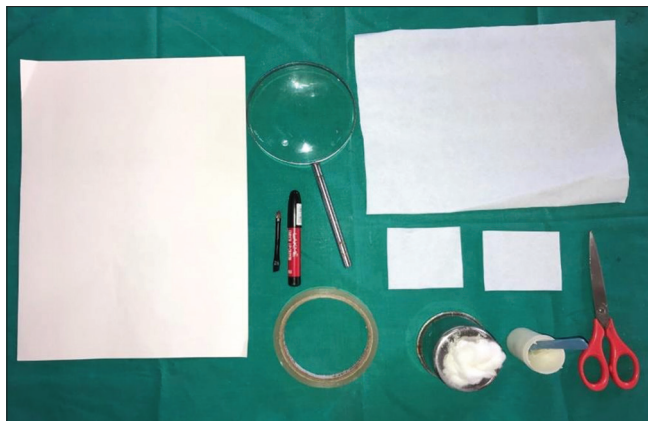2. Converging - Rugae with different origins from midline, but which joined on their lateral portions[14] [Figure 10].

All the details from each dental cast were observed as mentioned and documented in the data collection sheet.[10] Association between rugae forms and gender was tested using independent *t*-test.

STATISTICAL ANALYSIS

Collected data were analyzed by both descriptive and inferential methods. Independent *t*-test was used to estimate the total number of rugae and number of primary rugae. Chi-square test was used for determining the predominant shape, direction, and unification in palatal rugae and for the association of lip prints with gender determination in all the quadrants. Data were subjected to statistical analysis with the statistical package for the social sciences software (SPSS, version 22.0). United states, Chicago, Illinois owned by IBM
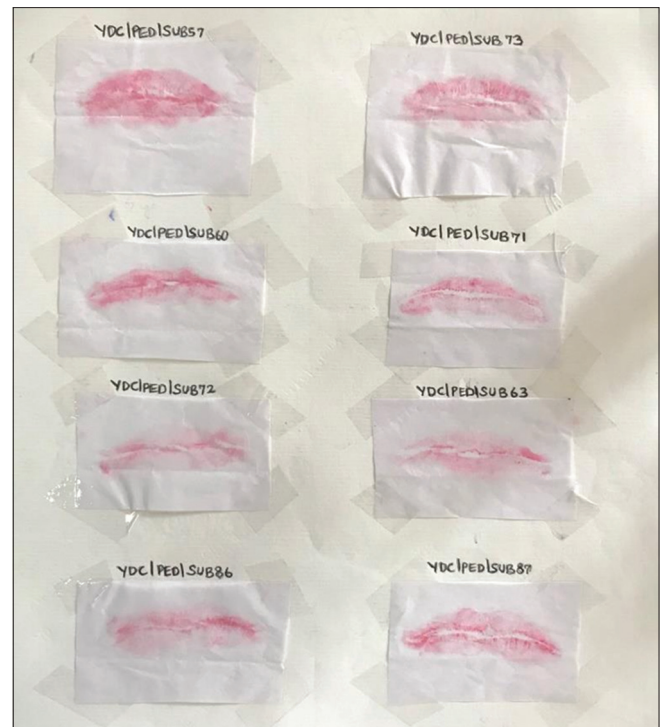

Figure 2: Coding of lip prints

Figure 1: Armamentarium for taking lip prints comprising of bond paper, magnifying lens, lipstick, lipstick brush, butter paper (starting from left from right)

Figure 3: Armamentarium for taking palatal rugae impressions comprising of perforated impression trays and impression material (starting from left to right)
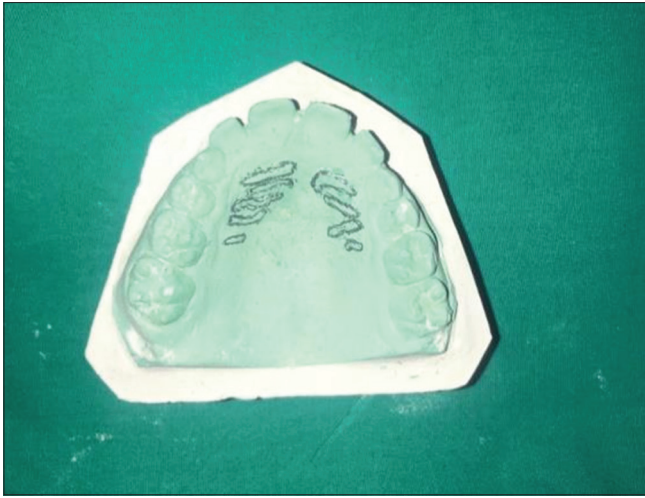

Figure 4: Curved shape

Figure 5: Wavy shape

Figure 6: Forwardly directed

Figure 7: Backwardly directed

Figure 8: Perpendicular

Figure 9: Diverging

Figure 10: Converging

RESULTS

A total of 92 healthy children (46 males and 46 females) with age ranging between 5 and 14 years who visited as outpatients in Yenepoya Dental College were randomly selected for the study.

Palatal rugae impressions and lip prints were taken and evaluated for parameters such as total number of rugae, number of primary rugae, predominant shape, predominant direction, unification, and different types of lip prints in all the quadrants, respectively.

PALATAL RUGAE PARAMETERS

a. Total number of rugae: In males and females, the mean value of the total number of rugae were 7.5435 ± 1.04789 and 8.2826 ± 0.88602, respectively There was very high statistically significant difference between males and females [Graph 1]
b. Number of primary rugae: In males and females, the mean value of the number of primary rugae was 6.6739 ± 0.94409 and 6.9565 ± 1.03186, respectively [Table 1 and Graph 1]
c. Predominant shape: The incidence of curved rugae was 41.3% and 39.1% in males and females, respectively. The incidence of wavy rugae was 52.2% and 58.7% in males and females, respectively. The incidence of straight rugae was 6.5% and 2.2% in males and females, respectively [Table 2]
d. Predominant direction: The incidence of forwardly directed rugae was 52.2% and 46.7% in males and females, respectively. The incidence of backwardly directed rugae was 23.9% and 22.2% in males and females, respectively. The incidence of perpendicular rugae was 23.9% and 31.1% in males and females, respectively [Table 3]
e. Unification: The incidence of converging rugae was 13.0% and 6.5% in males and females, respectively. The incidence of diverging rugae was 6.5% and 0.0% in males and females, respectively. 80.4% males and 93.5% females had no unification of rugae present [Table 4].

LIP PRINT PARAMETERS

a. Type 1: In the first quadrant, there was an incidence in 4.3% of males and 54.3% of females. In the second quadrant, it was 2.2% in males and 45.7% in females. In the third and fourth quadrant, it was 39.1% and 54.3% in females, respectively. There was very high statistically significant difference among males and females in all the quadrants with a $P < 0.001$ [Graph 2]
b. Type 1': In the first quadrant, there was an incidence 6.5% females. In the second and third quadrant, it was 10.9% and 34.8% in females, respectively. In the fourth quadrant, there is an incidence of 2.2% in males and 26.1% in females. There was very high statistically significant difference between males and females with a $P < 0.001$ [Graph 3]
c. Type 2: In the first quadrant, there was an incidence in 23.9% of males and 34.8% of females. In the second quadrant, there is an incidence of 6.5% in males and 37.0% in females. There was very high statistical significant difference between males and females with a $P < 0.001$. In the third quadrant, it was 2.2% in males and 13.0% in females. In the fourth quadrant, it was 2.2% in males and 15.2% in females [Graph 4]
d. Type 3: In the first quadrant, there was an incidence in 43.5% of males. In the second quadrant, it was 56.5% in males and 2.2% in females. There was very high statistically significant difference between males and females with a $P < 0.001$ in both the quadrants. In the third and fourth quadrant, it was 41.3% and 45.7% in males, respectively. There was very high statistical significant difference between males and females with a $P < 0.001$ [Graph 5]

Table 1: Number of primary rugae

Gender	*n*	Mean±SD	*T*
Males	46	6.6739±0.94409	1.37000
Females	46	6.9565±1.03186	*P*=0.174 (NS)

SD: Standard deviation, NS: Not significant

Table 2: Predominant shape

	Gender		Total
	Males[a]	Females	
Curved			
Count	19	18	37
Percentage	41.3	39.1	40.2
Wavy			
Count	24	27	51
Percentage	52.2	58.7	55.4
Straight			
Count	3	1	4
Percentage	6.5	2.2	4.3
Total			
Count	46	46	92
Percentage	100.0	100.0	100.0

[a]χ^2=1.203, *P*=0.548 (NS). NS: Not significant

Table 3: Predominant direction

	Gender		Total
	Males[a]	Females	
Forward directed			
Count	24	21	45
Percentage	52.2	46.7	49.5
Backward directed			
Count	11	10	21
Percentage	23.9	22.2	23.1
Perpendicular			
Count	11	14	25
Percentage	23.9	31.1	27.5
Total			
Count	46	45	91
Percentage	100.0	100.0	100.0

a. x^2=0.587 *P*=0.742 (NS). NS: Not significant

e. Type 4: In the first quadrant, there was an incidence in 21.7% males and 4.3% of females. There was a statistically significant difference between males and females with a $P = 0.027$. In the second quadrant, it was 23.9% in males and 2.2% in females. There was high statistically significant difference between males and females with a $P = 0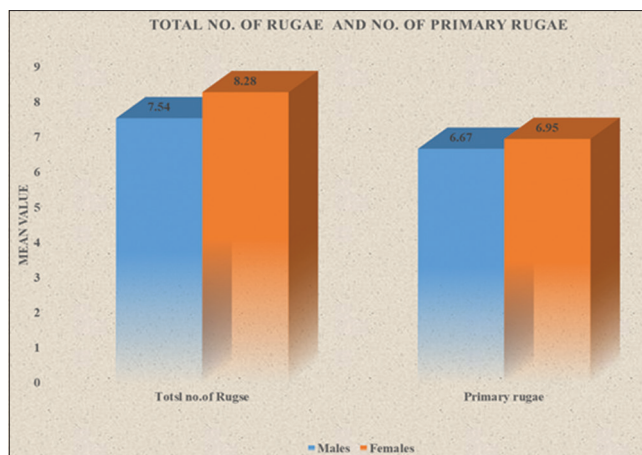.004$. In the third quadrant, it was 26.1% in males and 2.2% in females. There was high statistically significant difference between males and females with a $P = 0.002$. In the fourth quadrant, it was 37.0% in males and 4.3% in females. There was very high statistically significant difference between males and females with a $P < 0.001$ [Graph 6]
f. Type 5: In the first quadrant, there was an incidence in 6.5% males. In the second quadrant, it was 10.9% in males and 2.2% in females. In the third quadrant, it was 28.3%

Table 4: Unification of rugae

	Gender		Total
	Males[a]	Females	
Nil			
Count	37	43	80
Percentage	80.4	93.5	87.0
Converging			
Count	6	3	9
Percentage	13.0	6.5	9.8
Diverging			
Count	3	0	3
Percentage	6.5	0	3.3
Total			
Count	46	46	92
Percentage	100.0	100.0	100.0

[a]χ^2=4.45, *P*=0.108 (NS). NS: Not significant

Graph 1: Total number of rugae and number of primary rugae

Graph 2: Incidence of Type 1 in all the quadrants

Graph 3: Incidence of Type 1' in all the quadrants

in males and 10.9% in females. There was a statistical significant difference between males and females with a *P* = 0.036. In the fourth quadrant, it was 13.0% in. There was a statistical significant difference between males and females with a *P* = 0.026 [Graph 7].
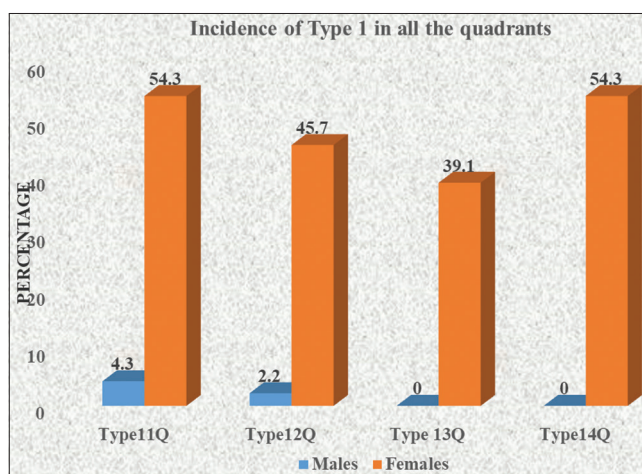
DISCUSSION

Cheiloscopy is applicable mostly in recognizing the living, since lip prints are usually left at crime scenes and can provide a direct connection to the suspect.[1] Palatoscopy may be used as a necroidentification technique which is of inestimable worth in ensuring the identity of people by making the use of antemortem data.[1]

In this study, for better accuracy of the lip patterns present in an individual, the lip has been divided into four quadrants in accordance to a study done by Venkatesh *et al*.[2] However, there are studies done by Sharma *et al*.,[1] Wazir *et al*.,[15] Chatra *et al*.,[16] and Spoorti and Saileela[17] where only the lower lip was taken into account. In another study by Vahanwala and Parekh,[11] it was shown that all four quadrants with the same type of lip prints were predominantly seen in female subjects and male subjects showed the presence of different patterns in a single individual. We also found Type 1, Type 1′, and Type 2 patterns to be dominant in females while Type 3, Type 4, and Type 5 patterns were dominant in males in almost all the quadrants, reinforcing previous observations. Forty-five males and females were correctly recognized as males and females, respectively, on the basis of their lip prints. This mismatch of males and females being identified incorrectly has been observed in a study conducted by Sharma *et al*.[1] In addition, we observed that no lip prints matched with each other and that lip print pattern was unique to every individual.
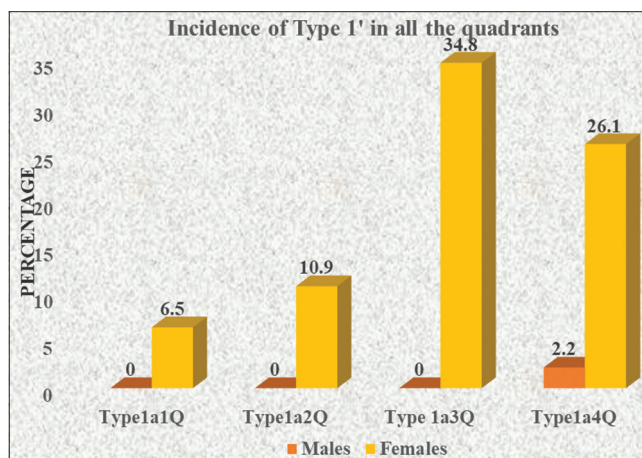
In this study, a female prediction was found to be higher in the total count and number of primary rugae as observed in a study conducted by Rajan *et al*.[18] This observation was in contrast to that of Shetty and Premalatha,[19] who reported that there was no significant difference in the total number of rugae in males and females in a study conducted in Mangalore. The predominant shape of the rugae in this study was wavy and curved among males and females with a lesser incidence of straight shape. These observations were in accordance with Byatnal *et al*.[20] and Shetty and Premalatha.[19]
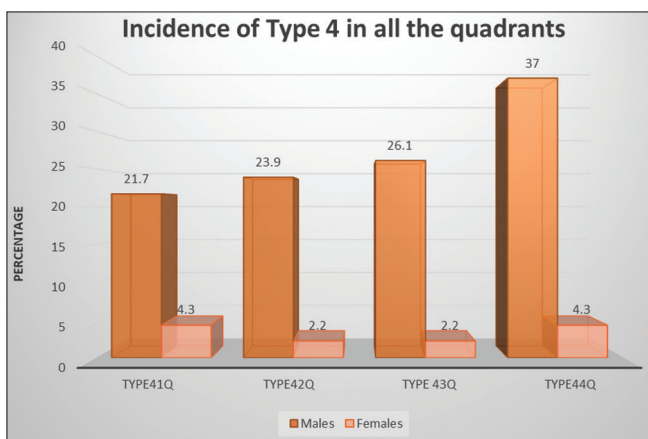
The incidence of forwardly directed and backwardly directed rugae was more in males and perpendicularly directed rugae were more in females. These observations were in contrast
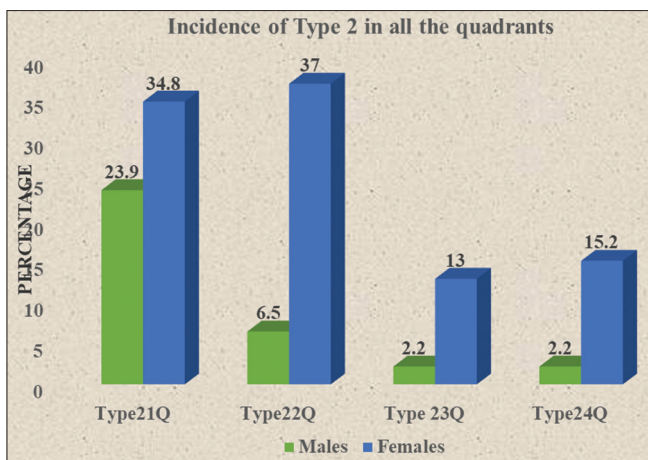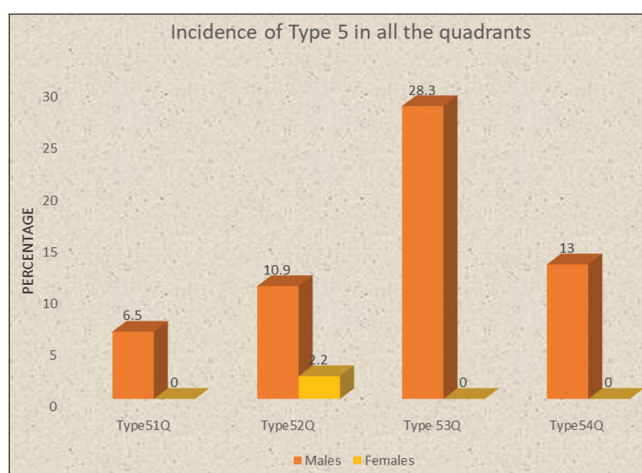
Graph 4: Incidence of Type 2 in all the quadrants
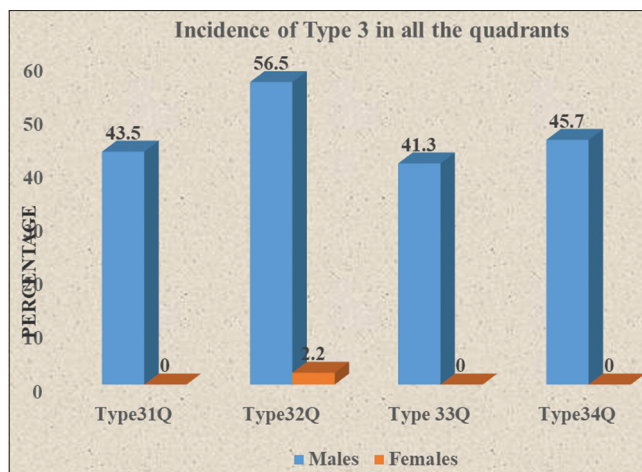
Graph 5: Incidence of Type 3 in all the quadrants

Graph 6: Incidence of Type 4 in all the quadrants

Graph 7: Incidence of Type 5 in all the quadrants

to a study conducted by Shetty and Premalatha[19] where forwardly directed were more in females and perpendicular and backwardly directed were more in males. Comparisons of the unification of rugae, that is, both converging and diverging did not show any specific trend. This was in agreement with the observations made by Shetty and Premalatha[19] and in contrast to the findings made by Jibi *et al*.,[21] who observed diverging pattern of palatal rugae in females and converging in males in a study conducted in Davangere, Karnataka. This study clearly demonstrates that palatal rugae are unique to each individual and rugae pattern with its different parameters can be used successfully as a tool of identification. Furthermore, no particular characteristic pattern of rugae was observed in either sex. However, it was confirmed beyond doubt that palatal rugae are distinctive to an individual.[19]

Studies conducted by Indira *et al*.[6] and Asdullah *et al*.[22] showed that rugae pattern was absolutely unique to an individual and could be used for identification. No inferences have been deduced between genders using palatoscopy in various studies. Differences in the shape of the palatal rugae in different races and population have been investigated but no significant sex differences were observed in those studies either.[19] This study clearly demonstrates that palatal rugae and lip prints are unique to each individual and be used

successfully as a tool of identification. However, lip prints are found to be more reliable than palatal rugae in identifying the gender of an individual.

CONCLUSIONS

It is an arduous, challenging, tiresome, and time-consuming process to identify living or dead people. Cheiloscopy and palatoscopy are unique to an individual and are rather straightforward techniques which do not require any complicated instrumentation; thus, their use in identification is fairly reasonable. The present study proves that both cheiloscopy and palatoscopy have the potential to identify an individual; however, lip prints are said to be more reliable in identifying the sex of an individual as compared to palatal rugae patterns. Along with the dentition, lip prints and palatal rugae can be used as a supplementary tool to establish the identity of an individual. It will be favorable to conduct studies with larger samples and to compare their inferences with ethnic groups to further validate the findings of this study and come to definitive conclusions.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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