Mandibular canine index, palatine rugae pattern and cheiloscopy as a predictor in sex determination: A Comparative Study

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Abstract

Introduction: Role of forensic odontologists is very important in identification of individuals in medico-legal cases and mass disaster calamities. Mandibular canine index, rugoscopy and cheiloscopy can play an important part in individual identification. This study was carried out to evaluate the significance of mandibular canine index, Rugoscopy and Cheiloscopy in sex determination.

Materials and Methods: A cross sectional study was carried out on 300 subjects, out of which 150 males and 150 females were selected from patients reporting the department of Oral Medicine and Radiology. Impressions of maxillary and mandibular arches were taken. The width of the canine and the intercanine distance were measured with digital vernier calipers, patterns of rugae were noted and impressions of lip prints were taken using lip color from every person.

Results: Mandibular canine index, Rugoscopy and different lip print patterns showed statistical significance in evaluating sex of a particular person.

Conclusion*:* This study showed that all three methods are reliable for sex determination. However, according to our study cheiloscopy was the better predictor of sex than the mandibular canine indices and palatal rugoscopy. It can be considered as a fairly predictable tool for sex determination in forensic odontology.

Keywords: Rugoscopy, Cheiloscopy, Mandibular canine index, Gender determination, Forensic odontology.

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Introduction

Teeth are considered as the vital components of the masticatory apparatus and being very hard structures, resistant to any kind of destructive forces therefore considered as a good source of material for civil & medico-legal identification[1]. Determination of sex is one of the significant aspects of forensic odontology. Morphological difference in the form, either in shape or size between individuals of different sexes can be termed as sexual dimorphism[2]. Sex determination by specific features of teeth is based mainly on the comparison of dimensions of the teeth in males and females.

The mean age of eruption of mandibular canines is about 10.87 years. They are least affected by the periodontal diseases and posses better resistance to severe trauma such as air disasters, storms and tornadoes or fire disasters. These attributes of mandibular canines can make them reliable to be used as the key teeth for personal identification[3].

Rugae patterns on the palate are unique and consistent in shape throughout life[4,5]. They are located anatomically inside the oral cavity which also helps to protect them from trauma and burning or charring due to fire. Other features such as shape, direction and unification remain consistent throughout life. It is difficult to describe the patterns of rugae qualitatively and quantitatively and they are unique to a particular person and hence considered a reliable method in identification of an individual[6] and is also effective means in determining sex of an individual.

Cheiloscopy is the study of grooves or furrows present on vermillion border of lips.[7] It is unique and used for sex determination as it remains constant throughout the life.[8] It was first described by R. Fisher in 1902.[9] As the patterns of prints of the lips are different in different individuals & varies in males & females it can help in determination of sex.

This study was done to determine the efficacy and compare mandibular canine index, palatine rugae pattern and cheiloscopy for sex determination.

Aims and Objective

1. To evaluate sexual dimorphism by using mandibular canine index, pattern of palatal rugae and chieloscopy.
2. To compare accuracy of mandibular canine index, chieloscopy and patterns of palatal rugae in sex determination.

Materials and Method

The study sample consisted of 300 patients, 150 males and 150 females between age group of 20-40 years reporting to the department of Oral Medicine and

Radiology, Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Wanadongri Road, Hingna, District Nagpur. Ethical committee clearance was obtained and informed consent was taken taken from all the patient included in the study.

All subjects were normal with no evidence of developmental anomalies, history of surgeries, trauma, orthodontic treatment, orthognathic surgeries, malocclusions, attrition, abrasion and erosion, or any other regressive changes of teeth, no caries, and normal molar and canine relationship. From each individual, the lip prints were recorded, maxillary and mandibular arch impressions were taken and casts poured so as to study the palatal rugae patterns and note the mandibular canine index.

Methodology

1. **Mandibular Canine Index:** Maxillary and mandibular casts were prepared. All measurements were carried out by a single examiner to eliminate inter-observer error. For assessment of intra-examiner error, the data collection procedure was repeated by randomly selecting the study models.[10]

To calculate mandibular canine index, following measurements were taken:

1. The greatest mesiodistal width between the contact points of teeth was measured to determine the width of mandibular canine on right and left sides of the cast.
2. Distance between tips of canines of the right and left sides of the cast was measured to find out the intercanine distance.

The mandibular canine index was calculated as follows:-

Mandibular Canine Index = Mesio-distal width of crown of mandibular canine / Intercanine distance

Sexual dimorphism in right and left mandibular canines was calculated using formula given by Garn and Lens (1967) as follows.

sexual dimorphism = $[\{Xm/Xf\} -1] \times 100$

Where X_m = mean value of males.

X_f = mean value of females.

2. **Palatine rugae pattern:** Alginate was used as an impression material on a perforated metal tray of proper size for the maxillary dental arch for all individuals. The impressions were then poured with Type III dental stone. Care was taken to avoid the presence of air bubbles and voids in the final casts.

The method of analyzing the rugae patterns in this study was based on the classification given by Thomas & Kotze and Kapali et al[11,12]. These classifications included number, length, shape and unification of rugae.

The rugae were highlighted by a black pen permanent marker on the cast under proper lighting and a magnification glass. A wire made of brass was adapted over the rugae and the length of wire was measured using a digital vernier caliper.

The following parameters assessed were:

A. Total number of rugae.
B. Number of primary rugae.
C. Predominant Shape.
D. Unification of rugae.

The rugae were classified based on their length as:

- Primary- >5mm.
- Secondary- 3 to 5mm.
- Fragmentary-<3mm.

Rugae which were less than 2 mm in length were not considered. A rugae's length was determined by measuring its greatest dimension in comparison with its shape.

On the basis of shape rugae were classified into 4 types:

a. Curved: They had a crescent shape.
b. Wavy: There was a slight curve at the origin or termination of curved rugae.
c. Straight: They run directly from their origin to termination.
d. Circular: Rugae that form a definite continuous ring.

Unification was considered when two rugae joined at their origin or termination:

1. Diverging: If two rugae had the same origin from the midline but immediately branched.
2. Converging: Rugae with different origins from midline, but which are joined on their lateral portions.

3. **Lip prints:** Dark colored, non glossy, non metallic with less moisture and oil content lip sticks were used to develop clear lip prints. White paper A_4 size, transparent cellulose tape and tissue papers were used in this process. Cleansing was done using wet tissue paper followed by application of a thin layer of lip balm, which was wiped off after one minute. A thin layer of lipstick was applied on the vermilion border and left for 3 minutes. Then a strip of cello tape slightly more than the breadth of the subjects lips were pressed from the right to left side of the lips. While recording the lip print adequate care was taken to ensure that the person's lips were relaxed and slightly separated. The tape carrying the lip prints was then pasted on white paper sheet.

The classification is as follows:[13,14,15]

Classification of patterns of lines on the lips given by Tsuchihashi Y:

1. Type I: Clear cut vertical grooves that run across the entire lips.
2. Type I': Similar to type 1 but that do not run across the entire lip.

3. Type II: Branched groove (branched Y pattern).
4. Type III: Intersected grooves.
5. Type IV: Reticular grooves.
6. Type V: Undetermined.

For classification, the middle part of the lower lip (10-mm wide) was taken as region for observation, as proposed by Sivapathasundaram *et al.*

The sex of the individual was determined as:

1. Type I, I' pattern dominant: Female.
2. Type I and II patterns are dominant: Female.
3. Type III pattern present: Male.
4. Type IV showing varied patterns: Male.

Statistical analysis was done for both the sexes using Chi Square test. The p value less than 0.05 were considered significant.

Results

For Mandibular Canine Index: Table 1 illustrates mandibular canine index of right side with mean value of 0.275962 in male and 0.266458 in female with p value of 0.031 which was statistically significant. Mandibular canine index of left side with mean value of 0.265673 in male and 0.258750 in female with p value of 0.078 was not statistically significant.

Table 1: Illustrates mesiodistal width of right and left mandibular canine, canine index and inter canine distance

Group Statistics							
	Gender	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**z value**	**P value**
Mesiodistal Width of canine(Right)	Male	52	7.788	0.5178	0.0718	4.466	<0.001 Highly Sig
	Female	48	7.344	0.4744	0.0685		
Mesiodistal Width of canine(Left)	Male	52	7.538	0.5318	0.0737	4.092	<0.001 Highly Sig
	Female	48	7.142	0.4272	0.0617		
intercanine distance	Male	52	27.67	1.593	0.221	2.128	0.036 Sig
	Female	48	26.94	1.861	0.269		
Mandibular canine index(Right)	Male	52	0.275962	0.0216	0.0029990	2.183	0.031 Sig
	Female	48	0.266458	0.0219	0.0031579		
Mandibular canine index(Left)	Male	52	0.265673	0.0178	0.0024679	1.778	0.078 Non Sig
	Female	48	0.258750	0.02118	0.0030455		

Table 2: Standard Canine Indices

Standard CI	Value
Right MCI	0.271
Left MCI	0.2631

Table 3 illustrates sex predilection using right and left side MCIs which shows that sex prediction on right side was noted to be 53.84% in 50 males and 54.16% in 50 female with overall accuracy of 54%. MCI on the left side was noted to be 36.53% in 50 males and 70.83% in 50 females with overall accuracy of 53%.

Table 3: Predictability of sex determination using Maxillary Canine Index

MCI	Sex	Cases	Percentage	Total
Right MCI	Males	52 (n = 100)	53.84%	54%
	Female	48(n = 100)	54.16%	
Left MCI	Males	52 (n = 100)	36.53%	53%
	Females	48(n = 100)	70.83%	

For Palatal Rugae Pattern: 100 maxillary dental casts obtained from 50 males and 50 females of Vidharbian subjects, were examined for the patterns of rugae by applying the classification proposed by Thomas & Kotze and kapali et al.

Total Number of Rugae: The mean value of total number of rugae in 50 males was10.83±2.046 and in 50 females was 10.42±1.843 with its P value of 0.296 .Total number of primary rugae found in males with mean value of 9.04±1.715 and in female 8.75±1.578 with its P value 0.385. Total number of secondary rugae found in male, with mean value 1.79±1.242 and in female 1.67±1.358 and P value 0.64. Gender wise, there were no significant difference found in the total number of rugae among the males and females. **Table 4**

Table 4: Total number of subjects and the mean value of rugae in males and females

Group Statistics							
	Gender	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**T value**	**P value**
Total no. of rugae	M	50	10.83	2.046	0.284	1.05	0.296
	F	50	10.42	1.843	0.266		
Primary	M	50	9.04	1.715	0.238	0.873	0.385
	F	50	8.75	1.578	0.228		
Secondary	M	50	1.79	1.242	0.172	0.468	0.64
	F	50	1.67	1.358	0.196		

Predominant Shape: The mean value of total number of straight rugae in 50 males and 50 females are found to be 1.83±1.465 and 1.75±1.229 respectively and its P value 0.778. Total number of wavy rugae found in 50 males with mean value 5.29±1.964 and in 50 females with mean value 4.92±2.019 and its P value 0.353. Total number of curved rugae found in 50 males with its mean value 3.50±2.110 and in 50 females with its mean value 3.48±1.701 and P value of 0.957. Total number of circular rugae found in 50 males with its mean value 0.10±0.358 and in 50 females with mean value 0.17±0429 with its P value 0.373. This study showed mainly the wavy pattern followed by curved, straight, branched and circular in both males and females. The incidence of circular rugae was more among the females as compare to males but it did not show any statistically significant difference. **Table 5**

Table 5: Descriptive statistics of different types of rugae categorized by sex

Group Statistics							
	Gender	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**T value**	**P value**
Shape of rugae							
straight	M	50	1.83	1.465	0.203	0.283	0.778
	F	50	1.75	1.229	0.177		
wavy	M	50	5.29	1.964	0.272	0.933	0.353
	F	50	4.92	2.019	0.291		
curved	M	50	3.50	2.110	0.293	0.054	0.957
	F	50	3.48	1.701	0.246		
circular	M	50	0.10	0.358	0.050	-0.895	0.373
	F	50	0.17	0.429	0.062		

Table 6: Illustrates comparisons of the unification of rugae both converging & diverging. The mean value of total number of converging rugae in 50 males and 50 females are 0.17±0.430 and 0.19±0.532 respectively and its P value 0.881. Total number of diverging rugae found in 50 males with its mean value 0.65±0.711 and in 50 females with mean value 0.31±0.589 with its P value 0.011. It showed a significant difference between male and female, and predominance of diverging rugae in males was seen.

Table 6: Unification of rugae

Group Statistics							
	Gender	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**T value**	**P value**
Unification							
converging	M	50	0.17	0.430	0.060	-0.15	0.881
	F	50	0.19	0.532	0.077		
diverging	M	50	0.65	0.711	0.099	2.60	0.011
	F	50	0.31	0.589	0.085		

Table 7: Illustrates that diverging rugaes were seen more in males as compared to females and more than 1 diverging rugae was found more in males. Percentage accuracy in male was 48% and female was 24% with total accuracy of 36%.

Table 7: Total no. of diverging rugae

Gender	Total no. of patients with diverging rugae out of 50	No. Patient with single rugae	No. Patient with two rugae	% Accuracy
Male	24	17	7	48%
Female	12	9	3	24%
Total	36	26	10	36%

For Lip Prints

The study of lip print pattern of 50 males and 50 females revealed the following observations.

1. No two lip prints matched with each other, thus establishing the uniqueness of the lip prints.
2. **Table 8** illustrate Type I & I' lip pattern present in 75.6% female and 24.4% of male, Type II lip pattern present in 83.3% females and 16.7% of males, Type III lip pattern present in 18.8% females and 81.2% of males, Type IV lip pattern present in 18.8% females and 81.2% of males, Type V lip pattern present in 20% females and 80% of males.

Table 8: Distribution of various patterns among male and female

Types of Pattern			Gender		Total
			Female	Male	
	Type I& I'	Count	31	10	41
		%	75.6%	24.4%	100.0%
	Type II	Count	10	2	12
		%	83.3%	16.7%	100.0%
	Type III	Count	3	13	16
		%	18.8%	81.2%	100.0%
	Type IV	Count	3	13	16
		%	18.8%	81.2%	100.0%
	Type V	Count	3	12	15
		%	20.0%	80.0%	100.0%
Total		Count	50	50	100
		%	50.0%	50.0%	100.0%

Table 9: Illustrates % accuracy of lip print patterns in sex determination.76% of males & 82% of females were identified correctly with total accuracy of 79%.

Table 9: Illustrates % accuracy of lip print patterns in sex determination

	% Accuracy
Male	76%
Female	82%
Total	79%

Discussion

Establishing a person's identity is important for medico-legal purposes and sex determination is an integral part of identification of an individual. Identification of a human being has always been of notable importance to society.[16] The routine methods for personal identification are, finger prints analysis, sex determination, age estimation, measurement of height, anthropometry, differentiation by odontology, blood groups and DNA testing.[17] Teeth being one of the hardest and least destructible structures help in forensic investigation to estimate age, determine sex and race of a person even in decomposed and burnt bodies..Recently palatoscopy cheiloscopy, and mandibular canine index, have gained popularity in forensic odontology because they are, predictable and easy to perform methods for human identification and sex determination on live or remains which are mutilated, and are cost effective, and easy to perform on post mortem and ante-mortem records.[18]

The present study compared mandibular canine indices of right and left side for sex determination. A statistically significant result in relation to sexual dimorphism of right side Mandibular Canine was observed.

Our study showed, lower values for sex prediction in males was 53.84% and in females was 54.16% using MCI of right side with percentage accuracy of 54%. The results on the contra lateral side i.e. left side using MCI showed 36.53% in males and 70.83% in females with percentage accuracy of 53%.

The findings of this study were almost similar to the study carried out by Parekh et al.[19], and Muller[19] et al. on Indian and French population respectively. They showed lower values for sex prediction i.e.50.5% in males and 49% in females using MCI of right side and 52.4% males and 50.8% females using MCI of left side. Thus, it was observed from our study that the chances of correct prediction of sex, using MCI is higher for males with overall percentage accuracy from right side MCI as compared to left side. The capacity to exhibit

sexual dimorphism and percentage accuracy varies in different studies and is based on different eating habits, genetics and influence of environmental factors.[20]

In mandibular canines the mesiodistal widths were significantly different in males and females. The mandibular intercanine distance also varied significantly in males and females. The mandibular canine indices thus showed quite a variation between males and females. The right mandibular canine was found to be more dimorphic than left mandibular canine.

The study of Palatal rugae has been done for large number of reasons; the foremost among them is personal identification and sex determination. In most of the studies the opinion is that, palatal rugae remains constant in number and does not show any change with growth, ageing, senescence, extraction of teeth and presence of diseases. Study of Palatal rugae is called palatal rugoscopy and has distinguishing characteristics which help in identity of a person. Trobo Hermosa a Spanish investigator first introduced Palatal rugoscopy in 1932[21]. In mammals the arrangement, occurrence and number of palatal rugae are specific to a species. In humans palatal rugae are asymmetrical which is an exclusive feature of human beings[22,23].

In the study that we carried out the most prominent pattern was found to be wavy, followed by curved, straight and circular patterns, which concurs with the other studies[24]. Divya et al[25] conducted a study in which the diverging pattern was predominant in females whereas in our study the diverging pattern was more prominent in males and more than one diverging rugae were found more in males. Therefore a bigger sample size is required to evaluate the reliability and variability. The percentage accuracy of palatine rugae pattern in determining sex was 36%.The uniqueness of palatal rugae pattern and its cost effectiveness makes it a reliable method of identification and sex determination in forensic odontology.

Cheiloscopy is a very useful tool in forensic investigation and sex determination. To classify lip prints Suzuki and Tsuchihashi in 1974 proposed a classification also known as Tsuchihashi's classification.[26] This is the most commonly used classification. It showed clear description and was easy to interpret.

According to Sivapathasundharam et al. (2008)[27], individualized patterns of lip prints depend on the relaxation of lip muscles. Leveque and Goubanova(2004)[28] mentioned that the furrows and groves on the lips provide channels for spread of saliva on the lips that helps to maintain its good moisture balance.

The study carried out by Karki RK[29] showed that type I pattern of lip prints is mostly found in males and type II is mostly found in females while type V has been found to be least commonly occurring variety. In a study carried out by Vahanwala & Parekh[15], type I& type I' are more commonly seen in females, and III, IV, and V are seen in males. In our study, Type I, I'& II were most commonly seen in females, whereas Type III, IV& V were seen most commonly in males and percentage accuracy for identifying sex was about 79%.

Nagalaxmi V et al[30] noted that the lip prints, patterns of rugae and mandibular canine index play an important part in identification of humans and sex determination, where lip prints are more significant in sex determination as compared to palatal rugae and mandibular canine index which was in agreement with our study.

Hence all the above three methods of sex identification hold importance as supplemental tools of forensic investigation.

Conclusion

This study was carried out to establish the role of mandibular canine indices, palatal rugae patterns and also cheiloscopy for identification of sex of an individual. The standard MCI is a quick and easy method for sex identification, when more advanced methods for sex determination are not readily available. This study showed that the lip prints were the best predictor of sex amongst the three methods. This study showed the importance and significance of each method but large scale studies are required to derive a definite conclusion.

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