A COMPARATIVE ASSESSMENT OF RELIABILITY OF RUGOSCOPY, CHEILOSCOPY AND MANDIBULAR CANINE INDEX IN SEX DETERMINATION

Dr. Mohammad Khaja Moinuddin[1*], Dr. Heena Zainab[2], Dr. Deepa Hugar[3], Dr. Ameena Sultana[4], Dr. Shahnaz Saba[5]

Abstract:

Background: In this world of simulation and impersonation, the identity of a given individual is always questionable. Many events that take place in the human journey between the *Womb to the Tomb*, may result in human destruction, by natural disasters like earthquake, tsunami, volcanic eruptions or a manmade disaster like plane crashes, train accidents and terrorist attacks, etc. In almost every disaster there is an urgent and pressing need to identify the victims on behalf of the next of kin. The various identification methods employed in forensic sciences include bite marks, radiographs, photographs etc. However in this era of biometrics, digital imaging technology, the future of investigation lies more in the comparative data/techniques like DNA profiling, fingerprints, odontometrics, Cheiloscopy, Rugoscopy etc.

Objectives: To assess, analyze and determine the reliability of cheiloscopy, rugoscopy and mandibular canine index in sex determination.

Materials & Methods: The study group will include a total number of 200 patients visiting the out-patient department for their routine dental checkup aged between 20-30 years.

Results: When the three methods were evaluated for sex determination and compared statistically, among them cheiloscopy (x^2 =67.32, $p<0.001$) & mandibular canine index ($t=9.93$, $p<0.001$) were very highly significant whereas rugoscopy ($x^2=3.76$, $p>0.01$) was not significant.

Conclusion: Forensic identification of living or deceased though is a tedious job but is a comprehensive work involving the coordinated efforts of multidisciplinary team employing different techniques in the face of which it also involves various other accessory methods like cheiloscopy, rugoscopy, odontometry, which are unique and show individual variations. Although there are many research studies on the above three methods, the studies comparing the three methods together with respect to reliability in sex discrimination are minimal.

Keywords: *cheiloscopy, rugoscopy, odontometry, forensic sciences*

[1*,4,5]Senior Lecturer, Al Badar Rural Dental College and Hospital, Kalaburagi, [2]Professor and Head, Al Badar Rural Dental College and Hospital, Kalaburagi, [3]Professor, Al Badar Rural Dental College and Hospital, Kalaburagi.

***Corresponding Author:** Dr. Mohammad Khaja Moinuddin
*MDS Senior Lecturer, Department of Oral Pathology and Microbiology. Al Badar Rural Dental College and Hospital, Near PDA Engineering college, Naganhalli road, Kalaburagi– 585102. Karnataka. India
E-mail address: dr.moin32@gmail.com

DOI: 10.48047/ecb/2023.12.si10.00335

INTRODUCTION:

Forensic dentistry is one of the most captivating and uncharted branches of forensic sciences, which deals with the identification of the suspects with the uniqueness of oral and maxillofacial structures.[1]

Every human has distinctive features and recognition of these plays a vital role in establishing human identification. Dental surgeon has an active role in various objectives of forensic dentistry like age, sex determination and personal identification of unknown deceased person. In forensic identification, the mouth has a myriad of possibilities.[2]

Identification includes a set of physical characteristics, functional or psychic, normal or pathological, that define an individual. Personal identification in civil and criminal cases and unknown deceased persons in homicide, suicide and accidents is a challenging subject. The identification of living persons is also required to assist with missing person enquiries and criminal investigation.[2]

The lip prints, palatal rugae prints and mandibular canine odontometrics are the alternative methods of forensic identification in cases such as car accidents, terrorist acts or mass disaster on which it's difficult to identify an individual through single samples.[3]

Lip prints are very useful in forensic investigations and are considered to be important form of transfer evidence, and are analogous to fingerprints. This forensic investigation technique which involves identification of humans based on lip traces is called Cheiloscopy. Lip prints which are accidentally left at the crime scenes can directly help in identifying the suspect.

Palatoscopy or Rugoscopy is the name given to the study of palatal rugae in order to establish person identity. The palatal rugae start developing during the third month of intrauteriune life and their morphological characteristics are stable throughout life.[4]

The advantages of palatal rugae as an ideal method of postmortem identification highlights that they are also protected from trauma by their internal location, also they are insulated from heat by the tongue and buccal fat pads[5].

Numerous methods using various body parts are in use to establish the identity in forensic studies. But the tooth, the most stable and hardest tissue in the body has been a useful adjunct in identification when other body parts cannot be used due to decomposition or mutilation. Almost all teeth are used in establishing one or the other parameter of identification. Canines, the most stable teeth bear the greatest degree of sexual dimorphism and play a highly valuable role in identification. Hence, their exclusive use in odontometric sex assessment using the tooth dimensions and canine index (CI) has been advocated before.[6] They are frequently the last teeth to be extracted, aned also bear a greater chance of surviving severe trauma. Thus, the mandibular canines are frequently used for human identification, and is often used as the methodology for sex estimation, being known for its simplicity and inexpensive application.[7, 8]

Aim:

1. To assess and compare the reliability of cheiloscopy, rugoscopy and mandibular canine index (MCI) as adjunctive tools in sex determination

Objectives:

1. To assess the reliability of cheiloscopy as a tool in sex determination.
2. To analyze the reliability of rugoscopy as an adjunct in sex determination.
3. To determine the reliability of mandibular canine index in sex determination.
4. To compare and contrast the efficiency of these three methods in determining sex of an individual.

MATERIALS AND METHODS:

COLLECTION OF DATA:

The present study was carried out on subjects visiting the outpatient department for their routine dental check-up. A study sample of 200 subjects comprising of 100 males and 100 females, with age ranging between 20-30 years and comprising of both sexes was included in the study. A written consent was obtained from the subjects and approval was taken from institutional ethical committee.

Calculation of sample size:

Sample size was estimated using the formula,
Sample size (n) = $Z^2_{\alpha}PQ/L^2$
Where n = Sample size
$Z\alpha = 1.96$ for 5 % significant level
P= Prevalence rate

Q= 100-P = 100-85.0 = 15.0
L = permissible error of P
= 6 % of 85.0= 5.1
Sample size (n) = $(1.96)^2$x85.0x15.0/ $(5.1)^2$
= 4947/ 5.1X5.1
= 191.1 (Round figure 200 sample were selected)
= 200 sample were selected in study

Inclusion Criteria:
- Lip and palate free from any abnormalities
- Morphologically sound canine teeth

Exclusion Criteria:
- Congenital anomalies of lip, palate and mandibular canine teeth
- Palatal swellings
- Traumatic injuries
- Orthodontic treatments
- Malocclusion

METHODOLOGY:

Cheiloscopy: For recording the lip prints, lips were initially wiped clean using tissue paper following which the lipstick was applied gently using a lipstick applicator from the central to lateral portion of the upper and lower lip with a single stroke. The subjects were then asked to clutch both the lips to ensure that the lipstick application was uniform. Following 2 min of waiting the glue portion of the cellophane tape was used to obtain the impression of the lip. This record was immediately transferred to a white bond paper by gently sticking the cellophane tape (Figure 1 and 2). Through this method, patient's permanent lip record could also be safely preserved for subsequent analysis.

Figure 1: Collection of sample for cheiloscopy

Figure 2: Lip prints stuck to white bond paper

For categorization of lip prints, the method proposed by Suzuki Tsuchihashi was followed.
- **Type I:** Clear – cut grooves running vertically across the lip.
- **Type I:** The grooves are straight, vertical but discontinuous, not running entirely across the lip.
- **Type II:** The grooves branch in their course in the shape of Y.
- **Type III:** Intersecting grooves.
- **Type IV:** Reticular pattern.
- **Type V:** The grooves do not fall into any of the types I – IV, and cannot be differentiated morphologically and are irregular.[6,9]

Rugoscopy: Alginate impressions of the maxillary arch of the same subjects were taken and models were poured in dental stone along with the plaster bases for further analysis. Palatal rugae were delineated with dark graphite pencil and the patters were analyzed using magnifying lens (Figure 3).

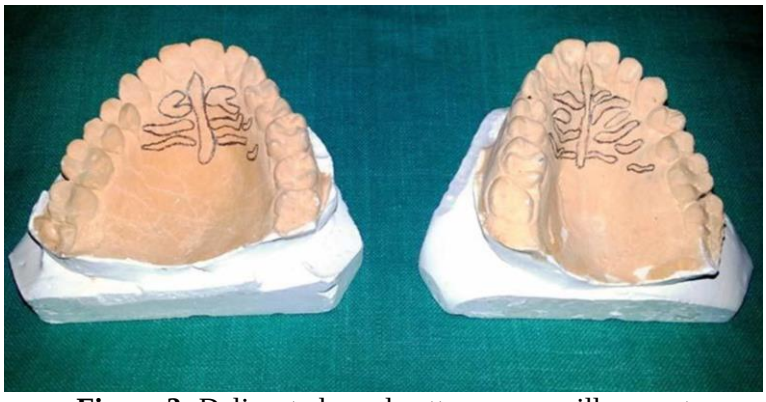


Figure 3: Delineated rugal pattern on maxillary cast

The rugae pattern will be studied by using the classification suggested by Lysell L (Figure 4,5,6).

The proposed classification of rugae patterns by Lysell L is as follows:

- **Straight:** They follow a straight or linear pattern from the origin to termination.
- **Curved:** They depict a crescent shape with a slight bend either at the origin or termination or both of the rugae under consideration.
- **Wavy:** Curved rugae with slight curve at the origin or termination in the wave form.
- **Circular:** Rugae that form a definite circular ring.
- **Unification (Diverging):** Two rugae with common origin but separate terminations.
- **Unification (Converging) :** Two rugae with separate origins but uniting at the termination laterally.[6,10]

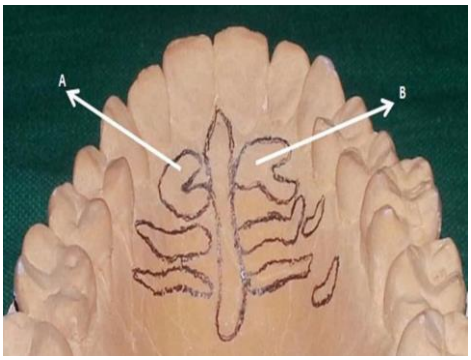


Figure 4: A. Unification converging type, B. Unification diverging type

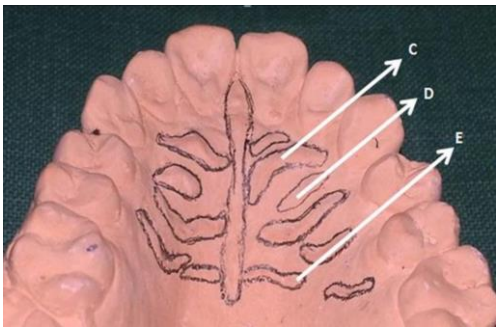


Figure 5: C. Curve type rugae, D. Straight type rugae, E. Wavy type rugae

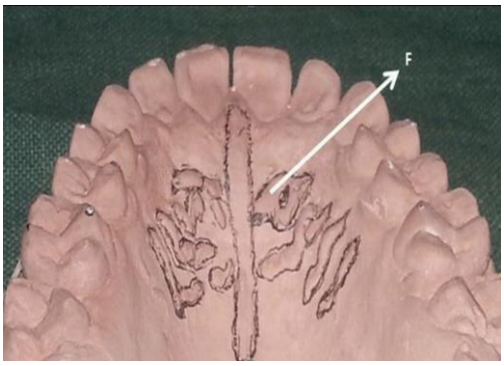


Figure 6: F. Other types of rugae

Mandibular Canine Index: The mandibular canine index was recorded intraorally using digital vernier calipers. The patient was asked to open the mouth wide, the two edge of the vernier calipers were adjusted in such a way that the mesio-distal width of right and left lower canine and the mandibular inter canine width are measured (Figure 7). These measurements were used to calculate the mandibular canine index by using the formula given by Rao et. Al.[6,11]

Mandibular canine index (MCI) = mesiodistal width of right and left lower canine (MDW) mandibular inter canine width (ICW)

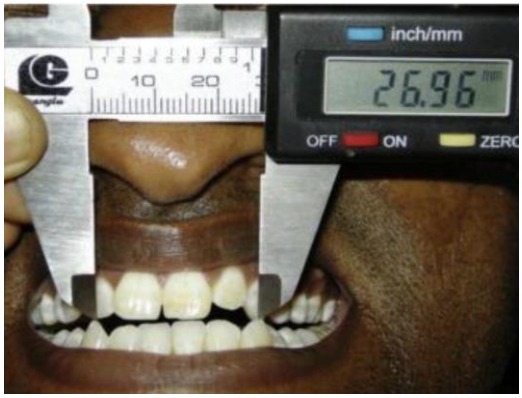


Figure 7: Recording of Inter-canine distance

Figure 8: Recording of mesio-distal width of canine

Statistical analysis:
Statistical data was analyzed by IBM SPSS 20.0 version software. Data was spread on excel sheet and calculated percentage, mean and standard deviation. For quantitative data analysis t-test was applied and for qualitative data analysis chi-square test was applied for statistical significance. If p value was less than 0.05 considered as significant.

RESULTS:
Cheiloscopy – All the samples (200) were collected and analyzed for lip prints. The predominant lip print patterns in males were type V (30%), type IV (28%), followed by other patterns like type III (18%), type I (6%) and type I'(4).

When females were evaluated for the lip prints, it was observed that type I (50%), type I'(22%) , patterns were seen predominantly followed by type II (10%), type III (6%), type IV (6%) and type V (6%).

The chi square value was found to be 67.32 and p value < 0.001 which is statistically very highly significant.

The results reveals that, there was statistically highly significant difference of patterns among males and females (P<0.001). Results observed that, in the patterns of Type I, Type I' and Type II female cases were significantly more than males (82.0%) whereas males cases were 24.0% in these patterns. The patterns of Type III, Type IV and Type V male cases were significantly more that was (76.0%) whereas female cases were (18.0%) in these patterns, (Table 1, graph 1).

Rugoscopy – When maxillary impressions were obtained and palatal rugae shapes were evaluated from all the samples (200) it was observed that in males the most commonly found pattern was wavy (94%), followed by curved (84%), diverging (68%), straight (22%0), converging (16) and other patterns (16%). However in females the most common pattern was diverging (74%), followed by wavy (68%), curved (66%), straight (32%), converging (12%) and other patterns (12%).
The chi square value was found to be 3.76 and p value > 0.05. Results reveal that there was no statistical significant difference of ruage shapes among males and females, (Table 2, graph 2).

Mandibular canine index – For obtaining mandibular canine index among 200 samples, intra orally a digital vernier calipers was used and the readings were obtained accordingly, inter canine distance (it is the linear distance between the cusp tips of right and left mandibular canine), right and left canine width (it is the greatest MD dimension of mandibular canine on either side of the jaw). Once the readings were obtained, they were evaluated for mandibular canine index using the formula given by Rao et al.

The results showed that among 200 samples the mean value for inter canine distance in males was found to be 26.86 with standard deviation of 1.49 and in females the mean inter canine distance was 26.28 with standard deviation of 1.46 where t = 3.06 and p value was < 0.005, which was statistically highly significant.

When the right canine width was measured, males showed a mean value of 7.02 with an standard deviation of 0.44, in females it was observed that the mean value was 6.43 and standard deviation 0.36, where t = 10.34 and p value < 0.001 compare to males, which was statistically very highly significant.

When the left canine width was measured, males showed a mean value of 7.03 with an standard deviation of 0.45, in females it was observed that the mean value was 6.45 and standard deviation 0.35, where t = 10.54 and p value < 0.001 compared to males, which also was statistically very highly significant.

The right mandibular canine index for males showed a mean value of 0.26 and standard deviation of 0.004 and in females it was observed that the mean value was 0.25 and standard deviation 0.003 where t = 9.93 and p value was < 0.001, and hence it was statistically very highly significant.

The left mandibular canine index for males showed a mean value of 0.28 and standard deviation of 0.005 and in females it was observed that the mean value was 0.26 and standard deviation 0.004 where t = 9.97 and p value was < 0.001, which was statistically very highly significant.

The results observed that gender identification using lip prints, showed there was statistically highly significant difference of patterns among males and females (p < 0.001), (Table 3, Graph 3).

When mandibular canine index was used to determine the sex among 200 samples, the number of samples correctly predicted were males (78%), females (66%), (table 4, Graph 4).

In palatal rugae patterns the results revealed that, there was no statistical difference of rugae patterns among males and females (p > 0.05).

MCI results revealed that there was statistically highly significant difference of mean canine measurements of mandibular canine among males and females (p < 0.001)

The reliability and efficiency of MCI in sex determination was found to be more compared to cheiloscopy, however rugoscopy showed non-significant efficiency in sex determination.

Table 1: Sex Wise Distribution Of Lip Prints Data

PATTERNS	MALES		FEMALES		TOTAL	
	No.	%	No.	%	No.	%
TYPE I	06	6.0	50	50.0	56	28.0
TYPE I'	04	4.0	22	22.0	26	13.0
TYPE II	14	14.0	10	10.0	24	12.0
TYPE III	18	18.0	06	6.0	24	12.0
TYPE IV	28	28.0	06	6.0	34	17.0
TYPE V	30	30.0	06	6.0	36	18.0
Total	**100**	**100.0**	**100**	**100.0**	**200.0**	**100.0**
χ^2-test, P-value & Significant	**χ^2= 67.32, P <0.001, VHS**					

NS= not significant, S=significant, HS=highly significant, VHS=very highly significant

Graph 1: Multiple Bar Diagram Represents Sex Wise Distribution Of Lip Prints Data

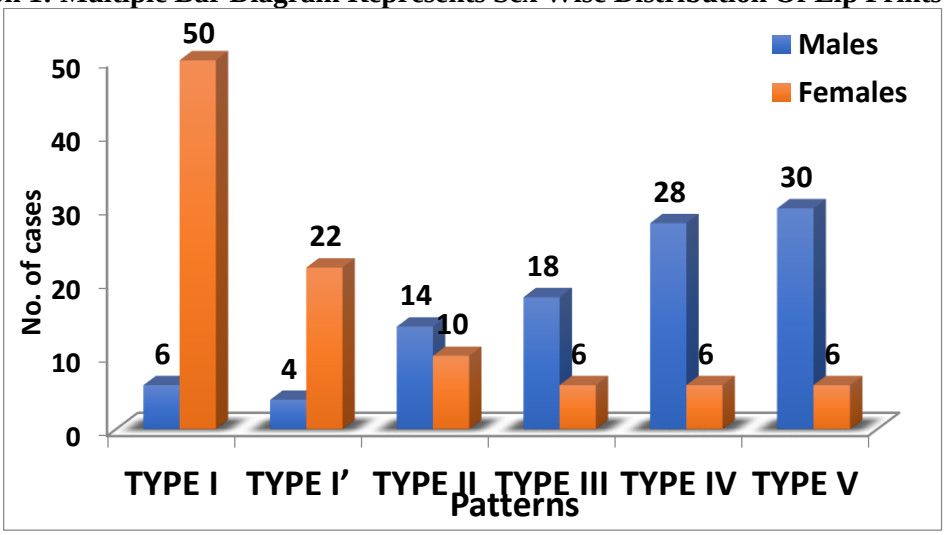


Table 2: Sex Wise Distribution Of Palatal Rugae Data

RUGAE SHAPES	MALES		FEMALES		TOTAL	
	No.	%	No.	%	No.	%
Curved	84	84.0	66	66.0	150	75.0
Wavy	94	94.0	68	68.0	162	81.0
Straight	22	22.0	32	32.0	54	27.0
Converging	16	16.0	12	12.0	28	14.0
Diverging	68	68.0	74	74.0	142	71.0
Other patterns	16	16.0	12	12.0	28	14.0
χ^2-test, P-value & Significant	**χ^2= 3.76, P>0.05, NS**					

NS= not significant, S=significant, HS=highly significant, VHS=very highly significant

Graph 2: Multiple Bar Diagram Represents Sex Wise Distribution Of Palatal Rugae Data

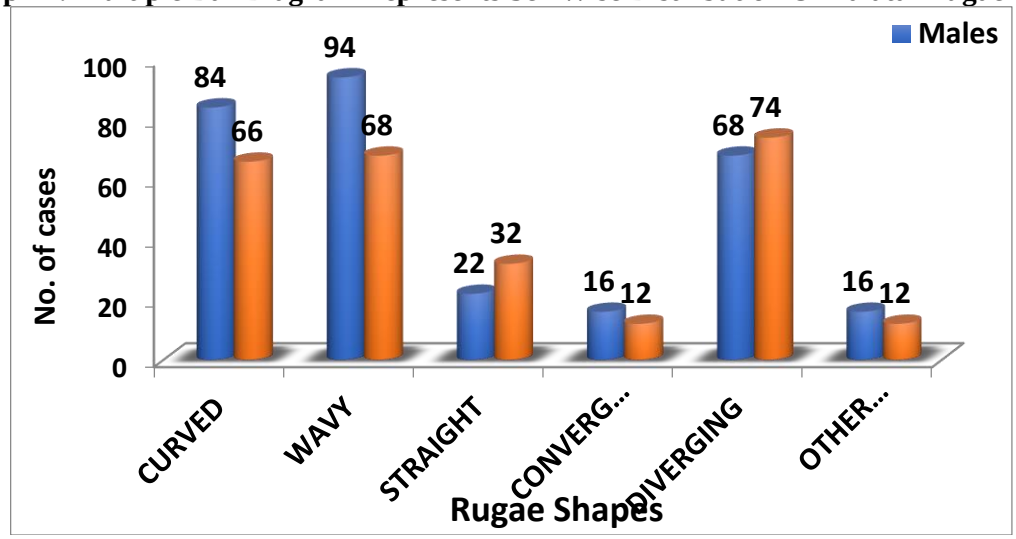


Table No 3: Sex Wise Distribution Of Mandibular Canine Index

MANDIBULAR CANINE INDEX	SEX	CANINE MEASUREMENT Mean ± SD	T-TEST, P-VALUE & SIGNIFICANT
Inter canine distance	Male	**26.86 ± 1.49**	**t = 3.06**
	Female	**26.28 ± 1.46**	**P<0.05, HS**
Right canine width	Male	**7.02 ± 0.44**	**t = 10.34**
	Female	**6.43 ± 0.36**	**P<0.001, VHS**
Left canine width	Male	**7.03 ± 0.45**	**t = 10.54**
	Female	**6.45 ± 0.35**	**P<0.001, VHS**
Right mandibular canine index	Male	**0.26 ± 0.004**	**t = 9.93**
	Female	**0.25 ± 0.003**	**P<0.001, VHS**
Left mandibular canine index	Male	**0.26 ± 0.004**	**t = 9.93**
	Female	**0.25 ± 0.003**	**P<0.001, VHS**

NS= not significant, S=significant, HS=highly significant, VHS=very highly significant

Graph 3: Multiple Bar Diagram Represents Sex Wise Distribution Of Mandibular Canine Index

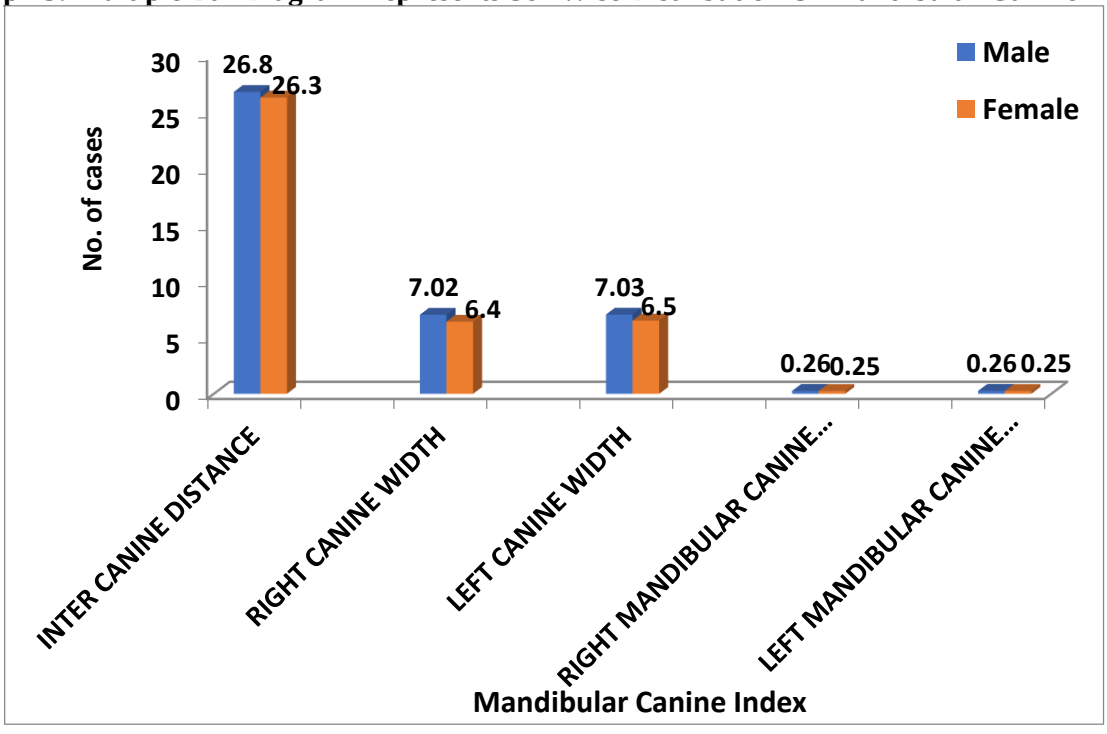
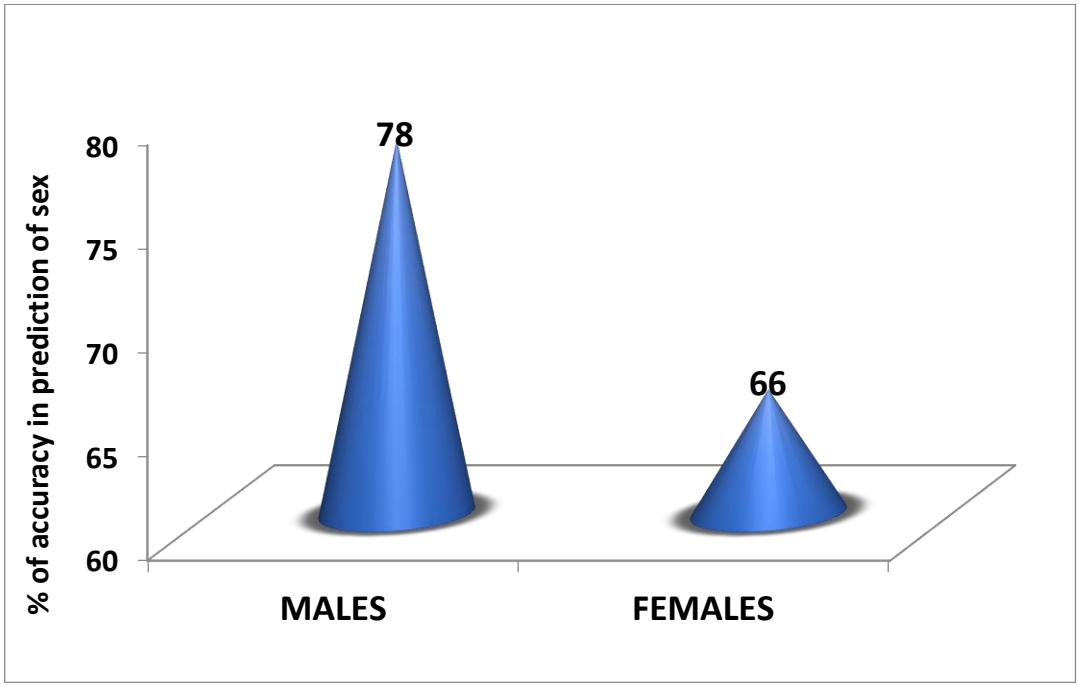


Table 4: Number Of Cases Correctly Predicted By Mandibular Canine Index

SEX	TOTAL NUMBER	PERCENTAGE OF ACCURACY IN PREDICTION OF SEX
Males	**78/100**	**78.0%**
Females	**66/100**	**66.0%**
Total	**144/200**	**72.0%**

Graph 4: Multiple Bar Diagram Represents Number Of Cases Correctly Predicted By Mandibular Canine Index



DISCUSSION:

Human identification is one of the most challenging subjects that man has been subjected to. In forensic medicine, palatal rugae, lip print and mandibular canine index can lead us to important information and help in person identification. The professional obligations of the dental surgeon is not only to serve by examination, investigation, diagnosis and treatment of oral and oro facial lesions and oral manifestations of systemic diseases, but also to serve in other community service and legal matters as well.

Determination of the individual by forensic methodology is warranted in cases of heirship, marriage, legitimacy, rape, identification of persons in disaster and child abuse. Criminals may conceal their gender by changing dress or by other methods. This can be detected by physical examination. In the absence of antemortem data, identification is usually established by the testimony of eye witness, with the advent of science and complicated technologies, man is been quite successful in deceiving "law". Mastering the law loopholes and masking sheer facts is very undemanding now. Hence, the criminal can be scot free by deceiving the law and misguiding the police as well as the investigators.

In the past decades, the palatal rugae print study (rugoscopy), lip prints (cheiloscopy) and odontometrics (mandibular canine) attracted attention of numerous scientists who declared the possibility of its utilization in the matter of human identification and gender determination. Comparative and correlation study on palatal rugae print, lip prints and canine odontometrics for the interpretation in personal identification and gender determination is meager in the literature.[6]

As these patterns are genotypically determined, the importance of using it for forensic investigations is justified as the patterns never undergo changes from birth until the body undergoes decomposition. Many studies dealt with possibility of uniqueness of palatal rugae print, lip print and canine odontometrics and the possibility of the presence of species and gender determination, but comparable and correlating studies are very scanty in literature. These studies pointed out that if this uniqueness and specificity

were proved, the palatal rugae prints, lip prints and canine odontometrics might be an important contrivance for identification.[6,8]

The present study was carried out in normal subjects with the prime objective to assess, analyze and determine the reliability of rugoscopy, cheiloscopy, and mandibular canine index (canine odontometrics) in the determination of gender of an individual.

Rugoscopy involves the study of palatal rugae pattern for human identification. Palatal rugoscopy was first proposed in 1932, by a Spanish investigator called Trobo Hermosa. The rugae formed at birth have a typical orientation which does not undergo any change except in its length during normal growth and stays in the same position throughout the life of a person. The occurrence, number, and arrangement of palatal rugae in mammals are species-specific. The rugae are protected from thermal insults and trauma by the tongue and buccal pad of fat, this anatomic position makes them stable and unique, hence they can be used as a parameter for human identification in the field of forensic medicine[2]. The present study was carried out to assess the shape of palatal rugae in 100 males and 100 females, based on the classification given by Lysell L.[9] The results revealed that there was no statistically significant difference in shape of rugae between the genders, the most predominant pattern in males was wavy pattern(94%) and diverging pattern(74%) appeared to be predominant in females. Our results were in accordance with that reported by Nayak et al. Similar results were obtained in Nepalese, Saudi, Egyptians, Australian Aborigenes and Caucasian population.[34] In contrast, Paliwal et al reported that straight rugae pattern was significantly predominant in males among Kerala populations when compared to Madhya Pradesh population.[38] Another study by Shetty S *et al*. (2005) revealed that Tibetan females had wavier pattern than their counterparts.[35]

The difference in rugae pattern observed in different racial group has been attributed to the interracial genetic differences[77]. Although rugae morphology may be influenced by environmental factors, it is mostly genetically controlled. It is claimed that during embryogenesis and postnatal growth, several genes determine the orientation of collagen fibers within rugae connective tissue and hence govern rugae pattern in various racial groups[78].

The term "Cheiloscopy" is derived from the Greek words *cheilos* meaning'lips' nd *eskopein* meaning 'to see'. Cheiloscopy (study of lip prints) is the forensic investigation technique that deals with identification of humans based on lip traces. Lip prints are normal lines and fissures in the forms of wrinkles and grooves present in the zone of transition of human lip, between the inner labial mucosa and outer skin. It is possible to identify lip patterns as early as the sixth week of intrauterine life. Thereafter, lip grooves pattern rarely change, resisting many afflictions[15] The importance of cheiloscopy is linked to the fact that, every lip print is different and unique and no two lip prints match with each other[81]. The pattern of wrinkles on the lips has individual characteristics as fingerprints, hence Lip Prints can be used to verify the presence or absence of a person at the crime scene[82].

Literature survey showed lip prints were recorded using 2 methods: lipstick and cellophane tape method and lipstick-paper-cardboard method. Bindal et al,. and Varghese et al., reported that the lipstick and cellophane method improved the visualization of the lip print compared to that of the later and also the later did not produced clear lip prints. Therefore in the present study lipstick cellophane tape method was followed. Sivapathasundarm et al in his study on lip prints suggested that middle part of lower lip was better suited for studying the lip patterns as this was most visible in the trace of lip. Therefore in the present study middle part of lower lip was considered for evaluation[85].

After studying all the collected lip prints carefully, it was concluded that the pattern found predominantly in the total study population, taking both lips together, was Type I (28%). This was followed, in order, by type V(18 %), type IV(17%), type I'(13%), type III (13%)and type II (12%). Our findings were in accordance with the studies done by Sharma et al[86]. and Neeraj et al[22]. A statistically significant difference in lip print patterns was observed in the present study between males and females. Type I was seen predominantly in females, whereas type IV and Type V were found in males. But studies conducted by Vahanwala and Parekh, Gondivkar et al suggested that Type III pattern was commonly found among males and type II among females[42]. While Sivapathasundaram[85], Manipady, Verghese *et al*., and Sandhu et al.,[84,25] ,reported in their study that Type III and Type II patterns in

males were predominant ; Type IV, and Type I were the predominant lip print patterns in females. The patterns of lip prints showed significant sexual dimorphism between males and females, and the difference in the results could be attributed to the difference in the race and ethnic origin of a person (Verghese et al. 2010). Petersen (2009) stated that lip prints of identical twins are not exactly identical and thus is unique[84,23].

The major drawback in lip print analysis is smudging and this could be overcome by using a good quality lip stick. Jaishankar et al. (2010) stated that subjects have to relax without stretching their lips during the process of lip measuring. Lip measurements can be inconsistent when the subject does not close it properly and relaxes it[25]. The effect of age and seasonal influences on lip print patterns remains an unknown factor, which needs further study.[28] Major trauma to the lips may lead to scarring and thus altering the pattern and morphology of grooves. Thus may give false results[28]

Lip prints form changes according to various causes of death (Utsuno et al. 2005), making lip prints a weak tool in identifying the person at death. Major trauma to the lips may lead to scarring and thus altering the pattern and morphology of grooves. Thus may give false results[28] According to Utsuno et al. (2005), clear and identifiable lip prints can be obtained when it is taken less than 24 hours following death[82]. Thus, cheiloscopy is applicable mostly in identifying living, since lip prints are usually left at crime scenes and provide a direct link to the suspect. In addition, cheiloscopy is a simple technique that does not require any complex instrumentations (Sharma et al. 2009)[86].

Although lip prints have previously been used in a court of law, the use is not consensual and some authors believe further evidence is needed to confirm their uniqueness. It is believed that lip prints are always a supplementary in the court of law. Regional population variation in prevalence pattern merits further study, and hence in future could gain more anthropological significance[19].

Sex determination is a vital step in reconstructing a biological profile from unidentified skeletal remains. Sex estimation is crucial in identification as it halves the number of possible matches. Odontometrics has been explored as a tool for sex assessment in the forensic literature mostly in the last twenty five years[87]. The major advantage of the dentition is that the inert, mineralized structures of teeth resist post-mortem degradation and survive deliberate, accidental or natural change better than any other skeletal structure.

The fact that most teeth complete development before skeletal maturation makes the dentition a valuable sex indicator, particularly in young individuals. The early permanent dentitions provide the best sample for tooth size measurements than early adulthood dentition as it has less mutilation and less attrition in most individuals[88].

Teeth being the hardest and chemically the most stable tissue, which exhibit the least turnover of natural structure in the body are selectively preserved and fossilized, thereby providing by far the best record for evolutionary change. Their stability in the face of fire and bacterial decomposition makes them very useful, excellent material in living populations for anthropological, genetic, odontological, forensic investigations, and identification[89].

Ditch and Rose[16] were the first to prove that teeth diameters can be successfully used in determining sex in poorly preserved and fragmentary skeletal remains in archeology. Mandibular canines exhibit the greatest sexual dimorphism among all teeth.[62] Canines differ from other teeth with respect to survival and sex dichotomy and are supported by their high level of survival in the dentition.

In our study when different parameters of the canine were compared, males have shown significantly greater dimensions than that of females which goes in accordance with the study conducted by Narang et al. This can be explained by the reason that Y chromosome increases the mitotic potential of the tooth germ and induces dentinogenesis, whereas X chromosome induces amelogenesis owing to the greater dentin and enamel thickness in males as compared to females[88].

According to Acharya and Minali (2009), teeth have behaved in many ways through the course of evolution, ranging from reduction of the entire dentition to reduction of one group of teeth in relation to other and this may be responsible for the low degree of dimorphism in some populations. Different human populations may show different expression of sexual dimorphism[72,75].

In some populations, this dimorphism may be greatly developed than in others. For so, any measurements of teeth unaccompanied by information about age, race and sex should be taken with great caution. It must be well born in mind that, studies which found no sexual difference in teeth size in some populations, do not necessarily contradict those which found such difference in others (Mughal et al., 2010)[72]
From our study it can be established that there is existence of statistically significant sexual differences between males and females regarding mandibular canine measurements. It is consistent with Hashim and Murshid (1993), who conducted a study on Saudi males and females and found that only the canines in both jaws exhibited a significant sexual difference while the other teeth did not[75].

Our study also confirmed significant differences between males and females in mesiodistal widths of mandibular canines, which are in agreement with other studies[75]. In our study we observed that the mean values for left and right mandibular canine mesiodistal width was less for females than for males, which was reported by AL-Rifaiy et al. (1997), who conducted a study on Saudi Arabian school of children and found the same results.

The results of the present work revealed that, the distance between sex means was higher in left canine than the right one and hence, left canine is more correlated to sex than the right. These results agree with those of Mughal et al. (2010), they reported a greater sex differences in the measurements of left mandibular canine. On the other hand, Lysell and Myrberg (1982), in their study reported that, the right mandibular canine showed maximum sexual dimorphism if compared with the left one. The finding that, teeth on one side are more correlated to sex more than the other side is not clearly understood but it may be due to genetic variability allowing complete growth of teeth on both sides at different times (Prathibha et al., 2009)[72].

The results of our study also go hand in hand with the results of Mughal et al. (2010) who performed their study on the lower canines using inter mandibular canine width.

In a mandibular canine index which was significantly higher in males than females. Interestingly, studies done by Acharya and Mainali, Prabhu and Karen et al. revealed a reverse dimorphism where the mean widths of canines were found to be larger in females than males. This could be attributed to the evolutionary process resulting in a reduction in sexual dimorphism in modern males and females[75,76]. The differences between canines' measurements in both sexes were reported to be due to the influence of the Y chromosome which affects the size of teeth by controlling the thickness of dentine, whereas the X chromosome is considered to be the chromosome responsible only for the thickness of enamel (Boaz and Gupta, 2009)[72].
However, reversed dimorphism; where the females showed larger teeth than males was found in the studies carried out by Acharya and Minali (2007) and by Yuen et al. (1999), where unexpectedly, the efficacy of mandibular canines for sex prediction had been denied.

There can be a complex interaction between a variety of genetic and environmental factors that might be responsible for the variation in the magnitude of dimorphism among population[72,75,76].

CONCLUSION:
Forensic identification of living or deceased though is a tedious job but is a comprehensive work involving the coordinated efforts of multidisciplinary team employing different techniques in the face of which it also involves various other accessory methods like cheiloscopy, palatoscopy, odontometry which are unique and show individual variations. Although there are many research studies on the above three methods, the study comparing the three methods together with respect to reliability in sex discrimination is minimal.

Our attempt of conducting this study gave a comparatively reliable significance of each method albeit large scale study is required in order to validate or substantiate our results to arrive at definitive results and values. However the present study proves that the lip prints, rugae patterns and odontometric measurements have the potential in human identification where mandibular canine odontometrics is more reliable in gender determination followed by lip prints. Though palatal rugae served as an identification method but it was not statistically significant.

Hence all the above three methods of sex identification holds importance as an ancilliary and supplemental tools of forensic investigations.

Ethical approval:

Ethical approval was obtained from the Institutional Ethical Review Board. Reference number: IERB/2016-17/16

Source of funding: Self

Conflict of interest: Nil

REFERENCES:

1. Goncalves AF, Diamantino F, Pestana D, Palmela Pereira C. the medico-legal importance of establishing human identity by palatal rugoscopy: evaluation of the immutability and individuality af palatal rugae under the influence of antemortemorthodontictreatment. Journal of forensic science and criminology 2014: volume 3: issue (3):1 – 12.
2. Nasreen Ishaq, ehsan ullah, Imran javad et al. cheiloscopy a tool for sex determination: professional Med J 2014: 21 (5): 883-887.
3. G satish kumar, N Vezhavendhan, Priya Vendhan. A study of lip prints among Pondicherry population. Jornal of forensic dental sciences: 2012: Vol 4: Issue 2.
4. S Manjunath, Shankar, M Bakkannaver, Pradeep Kumar G. palatal rugae patterns among the Indians at manipal, india. Jornal of pharmaceutical and biomedical sciences: Vol.20: Issue 20:1-5.
5. Lalit Kumar, Sandeep Agarwal, rajesh garg, amit pratap, B K Mishra. Gender determination using palatal rugae in the region of uttarakhand. J indian Acad forensic Med 2013: Volume (35): No.4.
6. Nagalaxmi V, Sridevi Ugrappa, Naga Jyothi M., Lalitha Ch. , Kotya Naik Maloth and Srikanth Kodangal. Cheiloscopy, Palatoscopy and Odontometrics in Sex Prediction and Discrimination - a Comparative Study. The Open Dentistry Journal, 2014, Volume 8, 269-279.
7. Vandana M Reddy, Susmita Saxena, Puja Bansal. Mandibular canine index as a sex determinant: A study on the population of western Uttar Pradesh. Journal of Oral and Maxillo Facial Pathology. Vol. 12 Issue 2 Jul - Dec 2008: 56-59.
8. Sunita Prashant Kulkarni et al. Mandibular canine index, palatine rugae pattern and cheiloscopy as. Predictor in sex determination. International Journal of Oral Health Dentistry; July-September 2016;2(3):154-160.
9. Tsuchihashi Y. studies on personal identifications by means of lip prints. Forensic sci 1974;3:233-48
10. Lysell L. Plicae palatinae transversae and papilla incisiva in man; a morphologic and genetic study. Acta Odontol Scand. 1955; 13(Suppl. 18):5-137.
11. Rao NG, Rao NN, Pai ML, Kotian MS. Mandibular canine index – a clue for establishing sex identity. Forensic sci 1989; 42:249-54.
12. Vimi S. Mutalik, Aparna Menon, Jayalakshmi, Asha Kamath, AR Raghu. The study of cheiloscopy, rugoscopy, and dactyloscopy for human identification. Journal of Forensic Dental sciences 2013: volume 5: issue 1:342-347.
13. Sylvie louise avon et al. forensic odontology: the roles and responsibilities of the dentist. J can dent assoc 2004: 70(7):453-458. (7)
14. Sharma p, saxena s, and rathod v. cheiloscopy: the study of lip prints in sex identification. J forensic dent sci. 2009: 1:24-7.
15. P. c. ibeachu, b. c. didia, and a. o. arigbede. A comparative study of palatal rugae patterns among igbo and ikwerre ethnic groups of Nigeria: A university of port Harcourt study. Anatomy research international volume 2014:5:97-102 (16)
16. Vijay kautilya d, pravir bodkha, Naveen rajamohan. Efficacy of cheiloscopy in determination of sex among south Indians. Journal of clinical and diagnostic research 2013: 2193-2196:54-59. (17)
17. Aleksandra Topczyłko, Krzysztof Borysławski, Dariusz Nowakowski. A comparison of sex identification methods based on lip furrow pattern. J forensic dent sci 1(1): 28-31
18. Bushra Karim, Devanand Gupta. Cheiloscopy and blood groups: aid in forensic identification. The Saudi Dental Journal (2014) 26, 176–180
19. Study of effect of age changes on lip print pattern and its reliability in sex determination. J Forensic Odontostomatol 2011;29:2:45-51
20. Collection of lip prints as a forensic evidence at the crime scene. Journal of Oral Health Research, Volume 1, Issue 4, December 2010, 130-135
21. Inheritance pattern of lip prints among among Nigerians. Sierra Leone Journal of Biomedical Research. Vol 9(2), pp.28-37, December, 2017-January, 2018
22. Determination of sex by cheiloscopy as an to establish personal identity. Open access. Jan-March 2018 | Volume 24 | Issue 1 | Page 29-33
23. El Domiaty MA, Al-gaidi SA, Elayat AA, Safwat MD, Galal SA . Morphological patterns of lip prints in Saudi Arabia at Almadinah Almonawarah province. 2010 Jul 15; 200(1-3):179.e1-9.

24. Augustine j, barpande sr, tupkari jv. Cheiloscopy as an adjunct to forensic identification: a study of 600 individuals. J Forensic Odontostomatol. 2008 dec 1; 26(2):44-52.
25. Dineshshankar, et al.: Lip prints: Role in forensic odontology. J Pharm Bioall Sci 2013;5:95-7
26. Dr. Surekha Rathod, Dr. Yogesh Rathod, Dr. Ishita Wanikar, Dr. Prashasti Sarode. Latent Lip Print, A Tool In Crime Investigation. International Journal Of Innovations In Dental Sciences / August 2017 / Vol 2 / Issue 2.
27. Multani, *et al*.: Lip prints: Can it aid in personal identification. Journal of International Society of Preventive and Community Dentistry. September-December 2014,Vol.4, No. 3
28. Prabhakar A Jeergal, Siddharth Pandit, Dinkar Desai, R Surekha, Vasanti A Jeergal. Morphological patterns of lip prints in Mangaloreans based on Suzuki and Tsuchihashi classification. Year : 2016 | Volume : 20 | Issue : 2 | Page : 320-327
29. Yogendra verma et al: Lip prints as a forensic tool. National Journal of Maxillofacial Surgery | Vol 6 | Issue 1 | Jan-Jun 2015 | 25-30
30. Kiran et al, Personal Identification using Cheiloscopy in South India.J Forensic Res 2016, 7:4, 2-4.
31. Indira. A.P, Gupta. M, David. M.P. Rugoscopy for Establishing Individuality. IJDA. 2011; 3(1):427-432.
32. Riboli.F, Gibelli. D, Cappella. C.C. Palatal Rugae as an Individualising Marker: Reliability for Forensic Odontology and Personal Identification. Science and Justice. doi:10.1016/j.scijus. 2011.09.002.
33. Bedia.A.S, Indurkar.B.A, Degwekar.C.S, Bhowate.C.R. Rugae Patterns as an Adjunct to Sex Differentiation in Forensic Identification. J Forensic Odontostomatol 2011;29(1):14-19.
34. Nayak. P, Acharya.A.B, Padmini A.T, Kaveri. H. Differences in the Palatal Rugae Shape in Two Populations of India. Archives of Oral Biology. 2007;52: 977-982.
35. Shetty.S, Shalini.K, Karthikeya.K, Mahima.V.G. Palatal Rugae Pattern in Mysorean and Tibetan Population. Ind J Dent Res. 2005;16(2):51-55.
36. Sharma.P, Saxena.S, Rathod.V. Comparative Reliability of Cheiloscopy and Platoscopy in Human Identification. Indian J Dent Res. 2009;20: 453-457.
37. Shetty. M, Premalatha.K. Study of Palatal Rugae Pattern among the Student Population in Mangalore. J Indian Acad Forensic Med.2011;33(2):2112-115.
38. Paliwal.A, Wanjari.S., Parwani.R. Palatal Rugoscopy Establishing Identity.J Forensic Dent Sci. 2010; 2(1):1-7.
39. Kapali.S, Townsend.G, Richards.L, Parish.T. Palatal Rugae Patterns in Australian Aborigines and Caucasians. Australian Dental Journal.1997;42 (2):129-33.
40. Valeria.H.V, Jaime.S.P.V, Mario.C.L, Iván C.S.G. Palatal Rugae: Systematic Analysis of its Shape and Dimensions for Use in Human Identification. Int. J. Morphol. 2009; 27(3):819-825.
41. Hauser.G, Daponte. A, Roberts. M.J. Palatal Rugae. J. Anal. 1989; 165: 237-249.
42. Govindkar. S.M, Patel. S, Gadbail. A.R, Gaikwad. R.N, Chole. R, V.Rema et.al. Morphological Study of Palatal Rugae Im Western Indian Population. Journal of Forensic and Legal Medicine. 2011; 18(3):310-312.
43. Bharath. S.T, Kumar. G.R, Dhanapal.R, Saraswathi. T.R. Sex Determination by Discriminant Function Analysis of Palatal Rugae from Population of Coastal Andhra. Journal of Forensic Dental Sciences. 2011; 3(2):58-62.
44. Fahmi F.M, Saleh. M.A.T, Yousef. F. Rugae Pattern in a Saudi Population Sample of Males and Females. Saudi Dental Journal, 2001; 13(2): 92-95.
45. Saraf.A, Bedia. A.S, Indurkar.B.A, Degwekar. C.S, Bhowate.C.R. Rugae Patterns as an Adjunct to Sex Differentiation in Forensic Identification. J Forensic Odontostomatol 2011; 29(1):14-19.
46. Manjunath. S, Bakkanavar.S.M, Kumar. P.G, Bhat.V.J, Prabhu.N, Kamath.A, Babu.R.Y.P. Palatal Rugae Patterns among the Indians at Manipal, India. Journal of Pharmaceutical and Biomedical Sciences. 2012; 20(20):1-5.
47. Kamala R, Gupta.N, Bansal.A, Sinha.A. Palatal Rugae Pattern as an Aid for Personal Identification: A Forensic Study. Journal of Indian Academy of Oral Medicine and Radiology. 2011; 23(3):173-178.
48. Patil.M.S, Sanjayagouda B, Ashith. A.B. Palatine Rugae and Their Significance in Clinical Dentistry A Review of the Literature. J Am Dent Assoc. 2008; 131(11):1471-1478.
49. Prabhu. R.V, John. B.J, Ariudinambi. S, Priya. G, Sayed. A.A.K. Morphology of Palatal Rugae among 5-15 Years Old Children.

Journal of Pharmacy and Bioallied Sciences. 2013;5(1):43-46.
50. Ismar. E.M.F, Helena. S, Peres. A.S, Carvalho. S.P.M. Palatal Rugae Patterns as Bioindicators of Identification in Forensic Dentistry. RFO. 2009;14(3):227-233.
51. Rafaela. F.D.M, Laise. N.C, Tinoco. R.L.R, Rabello. P.M, Silva. A.P.S, Eduardo. D.J. Palatal Rugoscopy as a Method of Human Identification. Odonto. 2010;19 (38):71-79.
52. Hemant. M, Vidhya. M, Nandaprasad. S, Karkare. B.V. Identification of Individuals Using Palatal Rugae: Computerized Method. Journal of Forensic Dental Sciences. 2010;2 (2):86-90.
53. Karine. C.D, Clemente. M.S. Fernandes. M.D.C.S. Evaluation of a Digital Methodology for Human Identification Using Palatal Rugoscopy. Braz J Oral Sci. 2011;10 (3):199-203.
54. Angelis.D, Riboli.F, Gibelli D, Cappella.A, Cattaneo.C. Palatal Rugae as an Individualising Marker. Reliability for Forensic Odontology and Personal Identification. Sci Justice. 2012;52(3):181-184.
55. Anukool H.P, Thakkar.K. Palatal Rugae a Stable Landmark. A Comparison Between Pre and Post Orthodontic Patients. International Journal of Dental Clinics. 2011;3 (4):9-12.
56. Parihar.A.Y, Vaid.N, Parihar.S. Plicae Palatine Transversae: Important Landmarks. Journal of Asian Pacific Orthodontic Society. 2010;1(2): 1-4.
57. Muthusubramanian. M, Limson K.S, Julian R. Analysis of Rugae in Burn Victims and Cadavers to Simulate Rugae Identification in Cases of Incineration and Decomposition. The Journal of Forensic Odonto-Stomatology, 2005;23(1):26-29.
58. Fouad A, Loubna S, Mohamad R, Antoine C, Randa D, Ibrahim Z, *et al*. Mandibular canine dimorphism in establishing sex identity in the Lebanese population. Int J Dent 2014; 52:1-4.
59. Dahlberg AA. Dental traits as identification tools. Dent Prog 1963; 3:155-60.
60. Gadiputi S, Masineni NS, Gayathri R, Ramesh N, Aditi M, Ashutosh A. Dimorphic mandibular canines in gender determination in Moradabad population of Western Uttar Pradesh.J Forensic Dent Sci 2015;7:32-6.
61. Dahlberg AA. Forensic dentistry. J Am Dent Assoc 1976; 93:991-5.
62. Kaushal S, Patnaik VV, Agnihotri G. Mandibular canines in sex determination. J Anat Soc India 2003; 52:119-24.
63. Parekh DH, Patel SV, Zalawadia AZ. Odontometric study of maxillary canine teeth to establish sexual dimorphism in Gujarat population. Int J Biol Med Res 2012; 3:1935-7.
64. Singh J, Gupta KD, Sardana V, Balappanavar AY, Malhotra G. Sex determination using cheiloscopy and mandibular canine index as a tool in forensic dentistry. J Forensic Dent Sci 2012; 4:70-4.
65. Ibeachu PC, Didia BC, Orish CN. Sexual dimorphism in mandibular canine width and intercanine distance of university of port-harcourt student, Nigeria. Asian J Med Sci 2012; 2:166-9.
66. Vishwakarma N, Guha R. A study of sexual dimorphism in permanent mandibular canines and its implications in forensic investigations. Nepal Med Coll J 2011; 13:96-9.
67. Marin Vodanovic. Odontometrics: a useful method for sex determination in an archaeological skeletal population?. Journal of Archaeological Science 34 (2007) 905e913
68. Pagare N. Study of Odontometric Parameters in Gender Identification. J Forensic Sci Criminol. 2017; 4(2): 1060.
69. Pettenati-Soubayroux, Michel Signolia, Olivier Dutour. Sexual dimorphism in teeth: discriminatory effectiveness of permanent lower canine size observed in a XVIIIth century osteological series. J Forensic Science International 2002; 126 :227–232.
70. Fouad, Hussein I. Abo EL Yazid A. Saudi and Hasnaa F. Ibrahim. sex determination from mandibular canines: A new radiometric method. Mansoura J. Forensic Med. Clin. Toxicol. Vol. XX, No. 1, January 2012.
71. Hashim, M. A. and Murshid, Z. A. (1993): "Mesiodistal tooth width in a Saudi population sample comparing right and left side, part 1". Egypt Dent. J., 39: 343-346.
72. Al-Rifaiy, M. Q.; Abdullah, M. A.; Ashraf, I. and Khan, N. (1997): "Dimorphism of mandibular and maxillary canine teeth in establishing sex identity". Saudi Dent. J., 9: 17-20.
73. Lysell, L. and Myrberg, N. C. (1982): "Mesodistal tooth size in deciduous and permanent dentitions". European Journal of Orthodontics, 4(2): 113-122.
74. Prathibha, R. M.; Mahima, V. G. and karthikeya, P. (2009): "Bucco-lingual dimension of teeth: An aid in sex determination". Journal of Forensic Dental Sciences, 1(2): 88-92.

75. Ch. Sai kiran et al. Role of mandibular canines in establishment of gender. Egyptian Journal of Forensic Sciences (2014) 4, 71–74.
76. Bashir T et al. Mandibular canine index in gender dimorphism. Journal of Indian Academy of Oral Medicine & Radiology | Volume 28 | Issue 4 | October-December 2016. 386-390.
77. Thomas CJ, Kotze TJ. J Dent Assoc S Afr 1983; 38(3): 153-157.
78. Dhoke M, Osato S. Morphological study of the palatal rugae in Japanese. 1. Bialteral differences in the regressive evolution of the palatal rugae. JPN J Oral Biol. 1994; 36:126–40.
79. Emiliya Taneva. Evaluation of Palatal Rugae in Identical Twins. Journal of Forensic Sciences, vol. 33, pp. 718–726, 1988.
80. Saraswathi tr, gauri mishra, raganthan k. study of lip prints. j forensic dent sci 1: 28-31.
81. Bharathi.s et al. cheiloscopy – lip print, an determination of sex and individual. j. pharm. sci. & res. vol. 7(6), 2015, 330-333
82. Utsuno H, Kanoh T, Tadokoro O, Inoue K. Preliminary study of post mortem identification using lip prints. Forensic Sci Int. 2005;149:129-32.
83. Bindal U, Jethani SL, Mehrotra N, Rohtagi RK, Arora M, Sinha P. Lip prints as a method of identification in human being. J Anat Soc India. 2009;58:152–5.
84. Varghese AJ, Somesekar M, Babu UR. A study on lip prints types among the people of Kerala. J Indian Acad Forensic Med. 2010;32:6–7.
85. Sivapathasundharam B, Prakash PA, Sivakumar G. Lip prints (cheiloscopy). Indian J Dent Res 2001; 12:234-7.
86. Sharma P, Saxena S, Rathod V. Cheiloscopy: The study of lip prints in sex identification. Journal of forensic Dental sciences. 2009; 1;1(1):24.
87. Anna P Joseph, Harish R.K, P K. Rajeesh Mohammed, Vinod Kumar R.B.how reliable is sex differentiation from teeth measurements. oral & maxillofacial pathology journal. vol 4. no 1. jan- jun 2013.
88. Divya Teja Dalli et al., Odontometrics: A Key to Gender Determination. World Journal of Dentistry, July-September 2016;7(3):150-154
89. Chourasiya S. Study of Odontometric Parameters in Gender Identification. Austin J Forensic Sci Criminol. 2017; 4(2): 1060.