RESEARCH ARTICLE

EVALUATION OFDIFFERENTPOTENTIAL BIOMETRIC IDENTIFICATION FORENSIC TOOLS LIKE TONGUE PRINTS, RUGAE PATTERNS AND FINGER PRINTS:A COMPARATIVE STUDY

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Manuscript Info	*Abstract*
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	Introduction-Biometric technologies are defined as the "automated methods of identifying or verifying of a living person based on a physiological or behavioral characteristic. With the help biometric in forensic we identify different biometric identification features like tongue prints, rugae patterns and finger prints. **Objective**-Objective of this study to assess and evaluate the efficacy of different biometric identification features like tongue prints, rugae patterns and finger prints. **Materials and Methods-** This study included 50 subjects, in which 25 were males (Group A) and other 25 were females (Group B). The study was conducted in the department of oral and maxillofacial pathology at DJ college of dental sciences and research, Modi Nagar Uttar Pradesh. **Statistical Analysis-** Chi Square test was used, and "P" value of <0.05 was considered statistically significant. **Result-** On comparing all three parameters, there is statistical significant difference in total no. of rugae patterns and size seen in both male and females. No statistical significant seen in texture ,shape,grooves and lingual apex of tongue. No significant difference seen in finger print pattern on both male and female. **Conclusion-** Most accurate biometric method for personal identification is palatal rugae as it is protected well from external environment. Also, for sexual dimorphism palatal rugae is best for gender identification compared with others parameters.

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Introduction:-

Forensic dentistry is a challenging and fascinating branch of forensic science that involves the application of dental sciences in the identification of deceased individuals through the comparison of ante and post-mortem records.Forensic odontology can be defined as a branch of dentistry, which deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings in the interest of the justice. The word forensic is derived from the Latin word "forensis" which means "before the forum" which simply means public discussions. The two modem usages of the word "forensic" are as a form of legal evidence and as a category of public presentation.[1]

The word "Biometrics" is derived from the Greek word's "bios" for life and "metron" for measurement. Therefore, biometric technologies are defined as the "automated methods of identifying or verifying of a living person based on

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a physiological or behavioral characteristic.3The whole biometric system is based on a pattern recognition system that helps in personal identification and verification by estimating the reliability and the accuracy of various physiological as well as behavioral characteristics owned by the individuals.[2]

Human tongue of each individual is different from one another which serve as a good source of evidence for biometric authentication. Tongue print or lingual impression is a new biometric authentication method used in forensics. Every tongue has its own lingual impression, because of its unique shape and texture. To begin with, the tongue is unique to each person in its shape and in its surface textures.[3]

Rugoscopy- rugae are elevations of the mucosa located in the anterior third of the palate that are asymmetric and irregular in nature, they are first seen in the third month of intrauterine life. The study of palatal rugae pattern for human identification". Rugae are an important and stable source for identification in edentulous patients and also are difficult to destroy during mass disasters.[4]

Forensic evidence of fingerprint is the field of forensic expertise related to the inference of the identity of source from the examination of all the friction ridge skin, namely the fingers, the palms, the toes, the soles, and their marks. But for the sake of simplicity, the text is mainly focused on fingerprints and finger marks. The extreme variability of the fingerprints derives firstly from the knowledge of the morphogenesis of the papillary ridges pertaining to embryology and secondly, from statistical researches pertaining to dactyloscopy. Dactylography or Dactyloscopy is the study of finger prints identification. The word dactylography is derived from two Greek words, daktylos meaning 'finger' and graphein meaning 'to write'. It is the study of the impressions of patterns formed by the papillary ridges on the bulbs of fingers and thumbs. It is taken with the help of printer sink on unglazed paper.[5]

Aim:-
To assess and evaluate the efficacy of different biometric identification features like tongue prints, rugae patterns and finger prints.

Material And Methods:-
The study sample considered of randomly selected 50 patients, in DJ college of dental sciences and research, Modi Nagar Ghaziabad, Uttar Pradesh, India in the age group 18 to 60 year who were healthy and free of congenital abnormalities, inflammation and trauma related to palate, tongue, fingers, and smoking habits and any history of systemic illness.The sample was divided in to two groups:-
•   Group 1: comprised of 25 males
•   Group 2: comprised of 25 females

Examination Of Tongue
Followed by informed consent obtained from subject before examination subjects were asked to rinse the mouth gently with water,Then the subjects were asked to protrude the tongue for the observers to analyze   and to take a picture of the tongue.The photographs were compared in terms of morphological features such as shape, depth and characteristics of fissure by two independent observer. Classification of tongue features by Stefanescu et al. (2014)[6]

Tongue texture	Shape of tongue	Longitudinal grooves	Lingual apex
Physiological Scrotal Geographic	Ovoid Ellipsoid Rectangular Pentagonal Trapezoidal to asymmetrical	Perceptible/imperceptible Rectilinear/twisty Superficial/deep	Sharp Septate

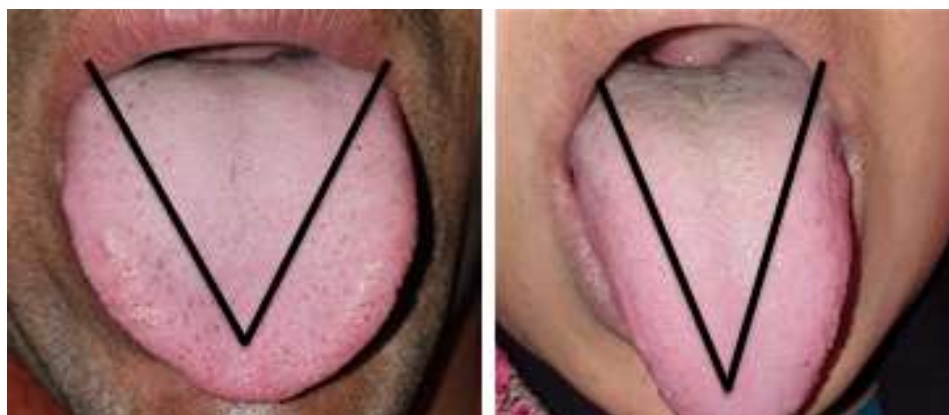**Figure 1:-** Reference points for determining the shape of the tongue are shown;(a) u-shape (b) v- shape.

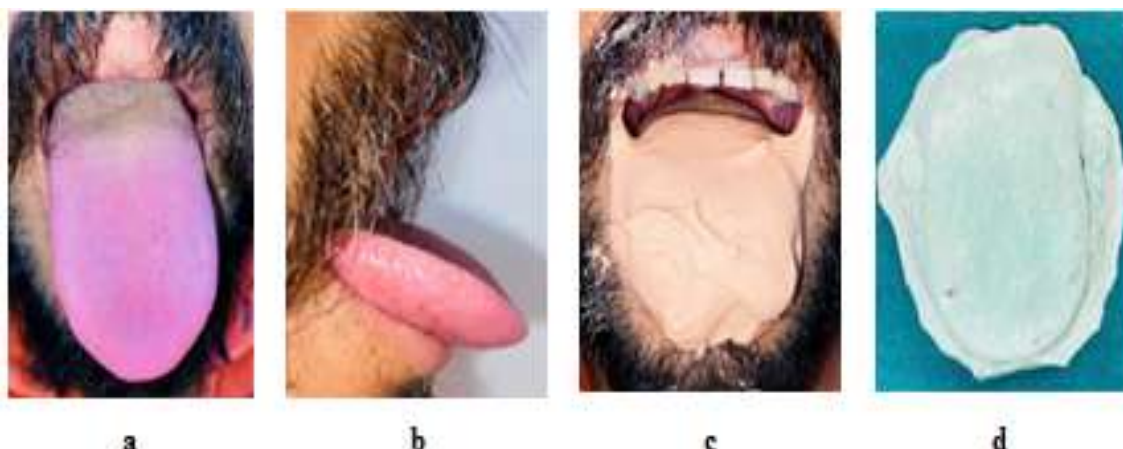a   b   c   d

Figure 2:-(a) male subject 23 years, examination of dorsum of tongue (b)examination of tongue edges; tongue aspects physiological protraction (c) applying alginate on the surface of the dorsum tongue from the level of the oral commissures up to the lingual tip including edges (d) tongue model by using dental stone (type IV).

Examination Of Rugae Pattern
A midline was drawn coinciding with that of the mid palatine raphae extending from the incisive papillae to the posterior most extent of the rugae on the palate. This divided the rugae in two halves and the rugae in each half were highlighted using a lead pencil under spot light by different examiners. Length of palatal rugae was measured with the use of manual Vernier Caliper (primary rugae, secondary rugae and fragmental rugae).
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Classifications used for palatal rugae patterns in 1983,Thomas and Kotze classification[7](Fig:4)

CIRCULAR	STRAIGHT	WAVY	CURVED	UNIFICATION

Figure 4:- Thomas and Kotze classification of rugae patterns; (a) circular (b) straight (c) wavy (d) curved (e) unification.

Examination Of Finger Print
Dermatoglyphic patterns of all 5 palmer digits were recorded using cummins and midlo method. The fingerprints were recorded as follows:

First of all, hands were scrubbed thoroughly with Savlon on and allowed to dry. After this right hand and left-hand digits were guided by the researcher to the ink stamp pad and pressed firmly against bond paper which was placed on a smooth surface board 3-4 times Once it has been established same procedure was recorded for thumb of right hand and thumb of left hand also. These dermatoglyphic patterns were analyses with the help of a magnifying glass (10x) with respect to available standards and data was tabulated.

Rugae Patterns

Finger Prints

Tongue Prints

Figure 5:- Photographs showing; male subject 25 years old (a) rugae patterns (b) finger prints (c) tongue prints.

Statistical Analysis
Findings were recorded, tabulated and subjected to statistical analysis.

Measurements for a total of 50 individuals (25 males and 25 females) were tabulated. The measured parameters were analyzed in SPSS version The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version.

The level of the Significance for the present study was fixed at 5% (α = 0.05). P-value <0.05 is considered to be statistically significant.

The intergroup comparison of the ordinal variable was done using Chi Square test and Continuous variables was done using the independent t test.

Result:-

On comparing the tongue texture among males and females, it was observed that physiological pattern of tongue was very common in both male and females. However, when considering sexual dimorphism, it has been observed that geographic and scrotal tongue only found in female patients.

The tongue shape among males and females, it was observed that ellipsoid shape of tongue was very common in both males and females. However, when considering sexual dimorphism, it has been observed that trapezoidal shape was found more in female and pentagonal shape of tongue was found more common in male patient.

The tongue longitudinal grooves among males and females, it was observed that superficial & twisty was very common in both male and females. However, when considering sexual dimorphism, it has been observed that imperceptible grooves was found more in female and deep & twisty was found more common in male patients.

On comparing the tongue lingual apex among males and females, it was observed that sharp tip was very common in both male and female. However, when considering sexual dimorphism, it has been observed that septate lingual apex was found more in male than female patients.

There is no statistical significant in tongue texture, shape, longitudinal grooves and lingual apex seen in both male and females.

On Comparing the number of rugae pattern among males and females, it was observed that higher no. of rugae in male than female patients.

On comparing the size of rugae pattern among males and females, it was observed that mean size of rugae pattern was 9.78 mm in male and 7.61 mm in female patients.

On comparing the direction of rugae pattern among males and females, it was observed that forward direction of rugae pattern was very common in male and female patients. However, backward direction more common in male than female.

On comparing the shape of rugae pattern among males and females, it was observed that wavy shape of rugae pattern was more common in female and circular shape was more common in male patients.

There is statistical significant difference in number, size, direction and shape of rugae pattern seen in both male and females.

The finger print pattern among males and females on right hand, it was observed that arch patternwas very common in male and whorl pattern was more common in female patients.

On comparing the finger print pattern among males and females on left hand, it was observed that loop pattern was more common in male and whorl pattern was more common in female patients.

There is no statistical significant difference in finger print pattern on left and right hand seen in both male and females.

It was found out that physiological texture of tongue was 100% in males and 92% in females, geographic and scrotal texture were 4% onlyfound in females, ellipsoid shape of tongue was 48% in male and 44% in females, trapezoidal shape was 24% in females and 8% in males, rectangular shape was 16% in both male and female, pentagonal shape was 24% in male and 12% in females and ovoid shape was found 4% in both male and females.

Also, superficial & twisty was 44% in males and 40% in females, imperceptible grooves was 44% in female and 32% in males, and superficial & rectilinear 8% in both male and female and deep grooves & twisty 16% in males and 8% in female and sharp tip was 92% in females and 80% in males, septate tip was 20% in males and 8 % in females.

On analysis of rugae pattern mean number of rugae was 9.44 in males and 9.28 in females whereas mean size of rugae was 9.78 mm in males and 7.61 mm in females. Also forward direction was 88% in females and 68% in males, backward direction was 32% in male and 12% in females, wavy shape was 84% in females and 40% in males, circular shape was 56% in male and 4% in female and straight shape was 12% in female and 4% in males.

On comparing finger print pattern on right hand loop was 33.6% in males and 30.4% in females, whorl was 35.2% in female and 28% in male and arch was 38.4% in male and 34.4% in female and finger print pattern on left hand loop was 45.6% in males and 35.2% in females, whorl was 38.4% in female and 24.8% in male and arch was 29.6% in male and 26.4% in females.

Table 1:- Inter observer variation for all the pattern.

	Observer 1 vs observer 2 features	Chi Square Value	df	Asymp. Sig. (2-sided)
Tongue print pattern	Tongue texture	0.000	2	1.000 (Non- sig)
	Tongue shape	0.735	4	0.947 (Non- sig)
	Longitudinal grooves	0.202	3	0.977 (Non- sig)
	Lingual apex	0.070	1	0.979 Non- sig)
Rugae pattern	No. of rugae	0.210	98	0.926 Non- sig)
	Size of rugae	0.002	98	0.838 Non- sig)
	Shape of rugae	0.053	3	0.975 Non- sig)
Finger print	Finger print pattern	0.034	4	0.998 Non- sig)

Based on table-1 there is no significant difference seen between two observers.

Table2:- Gender prediction based on tongue prints, rugae pattern and finger print pattern.

	Predicted Female		Predicted Male	
	Observer -1	Observer -2	Observer -1	Observer -2
Tongue print pattern	20 (80.0%)	19 (76%)	05 (20.0%)	06 (24.0%)
	15 (60.0%)	15 (60.0%)	10 (40.0%)	10 (40.0%)
Rugae pattern	20 (80.0%)	19 (76%)	05 (20.0%)	06 (24.0%)
	17 (68.0%)	17 (68.0%)	08 (32.0%)	08 (32.0%)
Finger print	19 (76.0%)	18 (72%)	06 (24.0%)	07 (28.0%)
	17 (68.0%)	16 (64.0%)	08 (32.0%)	09 (36.0%)

Based on table-2 The overall accuracy of tongue print pattern was 69%, finger print 70.0% and rugae patterns were 74%.

Table 3:- Overall accuracy of three methods.

	Accuracy	P value	Significant
Rugae patterns	74%	0.001	Significant
Finger prints	70%		
Tongue prints	69.0%		

Theabovetable:3 there is statistically significance seen on all three biometric methods(p value<0.05).

Discussion:-

Human identification is always a strenuous job, and forensic odontologist plays a pivotal role in this. It is essential in forensic sciences in which sex determinationwiththe help of oral structures of forensic dentistry is a subdivision of

human personalidentification.Both the hard and soft tissues in the head and neck region have unique characteristics that aid in such identification.[8]

In the past 10 years, numerous authors have proposed various imaging systems for collecting tongue prints, the first one being **Liu et. al**., in (2007).[9]

Akhil P. et al., (2016) discussed that tongue biometric can purpose an exceptionally trust worthy means for individual identification and act as a universal biometric in all solicitations.[10]

Our study state that, physiological pattern of tongue was very common in both male and female. However, when considering sexual dimorphism, it has been observed that geographic and scrotal tongue only found in female patients.

Another study carried out by **Vijay P, et al., (2019)** all showed similar findings concerning the predominance of scrotal tongue in females, while a contradiction was seen in the occurrence of geographic tongue, more being presented in the males than the females.[11]

On contrast to our study **Abraham J, et al., (2018)** in their study they found that morphologic study of the tongue, found that geographic tongue was more predominant in their subjects which was not found in our study.[12]

In this present study, ellipsoid shape of tongue was very common in both male and female. However, when considering sexual dimorphism, it has been observed that trapezoidal shape was found more in female and pentagonal shape of tongue was found more common in male patients.

No other studied were carried out, on the basis of shape as ovoid, ellipsoid, rectangular, pentagonal and trapezoidal. All other studies they compared based on U and V shape of tongue.

In our study among male and females we found that superficial & twisty was very common in both male and female. However, when considering sexual dimorphism, it has been observed that imperceptible grooves was found more in female and deep & twisty was found more common in male patients.

Venkatesh, et al., (2019) found that Shallow fissures (69.2%) were more common than deep fissures (30.8%). Females have a higher number of both deep (62.3%) and shallow (61.8%) fissures compared to males.[13]

In our present study, sharp tip was very common in both male and female. However, when considering sexual dimorphism, it has been observed that septate lingual apex was found more in male than female patients.

Hence, we can say that tongue is unique to every person with respect to its shape and surface textures. Since it is an internal organ, it can be easily exposed for inspection and the exposed surface carries the required information. The physiological texture and shape remain constant. It is well protected from the external environment, and so it is not affected by external factors. It is also a reliable proof of life. In recent years, tongue print is gaining momentum as an important tool in biometric authentication.[14]

Palatal rugae are important in forensic investigations. Ante-mortem records can be kept so it is responsibility of government to maintain these records for future.

Alani MM, et al., (2016) found that male have higher no. of rugae compared to female.[15] In contrast to our study **Surekha R, et al., (2012)** they showed in their study, that female has higher no. of palatal rugae than male.[16]

Balgi, et al., (2014) found that average length of the rugae was greater in males than in females.[17]

Paliwal A, et al., (2010) female has more no. of wavy pattern of rugae than male.[18] In contrast to our study. **Kumar S, et al., (2012)** conducted a study regarding palatal rugoscopy among Puducherry population and found that wavy pattern was most prominent followed by curved, straight, branched and circular pattern in both the genders.[19]

In our study,compare the number of rugae pattern among males and females, it was observed thathigher no. of rugae in male than female patients.the size of rugae pattern among males and females, it was observed that mean size of rugae pattern was 9.78 mm in male and 7.61 mm in female patients.it was observed that forward direction of rugae pattern was very common in male and female patients. However, backward direction more common in male than female.

On compare the shape of rugae pattern among males and females, it was observed that wavy shape of rugae pattern was very common in female and circular shape was more common in male patients.

Fingerprint patterns are genotypically determined and remain unchanged from birth till death.

Srilakha, et al., (2010) conducted a study during 2000-2001 on 300 medical students with different ABO blood groups in Rajasthan which revealed that arch pattern of fingerprints is more common in male.[20]**Sam, R. et al., (2013)** in their study found that each finger print is unique; loops are the most commonly occurring fingerprint pattern while arches are the least common. Males have a higher incidence of whorls and females have a higher incidence of loops.[21]

In our study, on compare the finger print pattern among males and females on left hand, it was observed that loop pattern was more common in male and whorl pattern was more common in female patients.

No previous study in literature had done comparison of three parameters in forensic i.e., tongue prints, palatal rugae patterns and finger prints, it is compared for the first time in our study. Not much research has been done on a replica of the tongue for personal identification.No such study conducted on tongue and to assess its, role in personal identification.

Conclusion:-
The most challenging situation in forensic odonto-stomatology are mass disasters, where the forensic dentist is usually confronted with charred human remains or heavily decomposed or fragmented bodies the rugae.

Tongue prints, as a new biometric authentication method has been found beneficial for identification although in India this identification system is still at grass-root level and needs more amount of research and planning to implement and dentist can play an important role to make tongue prints as a widely available and acceptable tool.

This study demonstrated that most accurate biometric method for personal identification is palatal rugae as it is protected well from external environment. Also, for sexual dimorphism palatal rugae is best for gender identification compared with others parameters.

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