

Tongue Print as an Identification Tool: A Study among the Dakshina Kannada Population

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Abstract: A new personal identification method has always had its contribution in identifying the human being and the use of lingual impression or tongue print as one of the methods of biometric authentication. The dorsal surface of the tongue with its features exhibits differences even between identical twins but is also useful in conjunction with cheiloscopy and rugoscopy in forensic dentistry. The classification of tongue with its shape and texture has to be elucidated and which makes the identification method easier.

Keywords: Tongue Print, Shape of Tongue, Texture of Tongue.

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I. INTRODUCTION

Tongue is a vital organ present in the oral cavity that has its unique features which can be distinguished with other individuals. It is unaffected by the external environment and gives a greater amount of information about its uniqueness like shape, texture and pattern. Tongue print or tongue replica are the terms collectively used for these patterns and being characteristic to every individual. The geometric shape and the physiologic texture do not vary much and like fingerprints nevertheless two tongues are identical even in case of twins. Various studies have shown that based on shape and texture, one can distinguish the sex having U and V shaped tongue. Fissure types, depth and their number have an adjuvant role in identifying male and female tongue as per gender wise distribution¹. The features on the surface of the tongue mainly inform its advantages over the other different biometric identification systems and highlights the different ways to extract the salient features on the tongue. In Traditional Chinese Medicine, the tongue is known to be a mirror of oral and general health because of its uniqueness and vitality in the oral cavity and is well described as the “tongue of life”². The dark and withered appearance of the tongue is termed as “tongue of death” in TCM. It is the proof of life that the individual is alive or dead and protrusion of the tongue is possible when alive. Death can happen when the tongue falls back to obstruct the airway, especially in sleep apnea³. Shape, texture and colour reveal visible differences but inform about health status and also a tool in personal identification². The organ tongue is made of skeletal muscles, blood vessels, nerve supply and in addition to it with papillae and taste buds. It's been observed and

stated in TCM that general texture varies between individuals³. The human tongue is very well preserved in the oral cavity and is easily protruded outside for clinical observation and can be inspected and palpated thoroughly. It helps us to deliver much information about its uniqueness and identity recognition. Fingerprint, retinal scan, skin color, voice check, palm print, face scan, signature check etc are the various biometric systems which have been employed for the security purposes⁴. These systems have their own advantages and disadvantages like an injury or burn, surgery or a heavy duty work can alter or erode the fingerprints and make them unstable. Voice can be affected by sickness like cold and cough. A highly sensitive method like retinal scan can get affected by astigmatism, cataract and bright light. Skin color or appearance changes as age advances, even disease and medications can lead to problems.²

Geographic or scrotal tongue, sharp tip, decreased length and breadth of the tongue in comparison with male tongue were considered to be the character features of female subjects in sexual dimorphism⁵. Tongue being the only internal organ which can be displayed for inspection and palpation purposes, its morphological categorization and analysis with various techniques are necessary in human identification^{6,1}. Tongue prints have their uniqueness and may constitute a secure method for forensic dentistry identification even in different populations and ethnicities. A comparison between tongue print, rugae pattern and lip prints always aid in narrowing the human identification process in forensic dentistry^{7,8}.

Tongue prints or lingual impressions of the dorsal surface with lateral borders when used in conjunction with methods such as cheiloscropy and rugoscopy, proved to be useful in forensic dentistry^{8,9}. The challenging areas that a man has been confronted with are human identification and forensic odontologist deals mainly with the uniqueness of the organs especially in an individual's oral structures. Tongue is also considered to be a unique vital organ which promises to deliver uniqueness with its many properties suitable for identity recognition¹⁰. A clinical study is undertaken in support of uniqueness of tongue and also as a tool in the field of forensic odontology.

II. REVIEW OF LITERATURE

Liu and Zang (2007) have carried out a study which was designed to develop a tongue image database with shape and surface texture of individuals, in Hongkong Polytechnic University. The sample size of the study was 134 subjects with a newly developed 3D tongue image database. This database was considered to be a valuable resource for comparison, assessment and evaluation, also an attempt to make 3D tongue images available for the research community. The ultimate goal of the study was to foster the research on tongue biometrics and also a valuable resource for algorithm assessment and evaluation¹¹. Diwakar & Maharshi (2013) have conducted a computer based study to present the geometric shape and physiological texture of the tongue, which were useful in identity verification applications. The population size, age and type of sample were not the criteria but different shapes of the tongue used as a parameter and calculated by using control points and were resulted as prominent outlines of shape features of the tongue. The texture feature was calculated by SIFT algorithm method and pre-processed by histogram equalization. They were able to demonstrate in two phases, first to find out spots on the tongue with the help of histogram and the second phase to extract tongue image and recognize it from the tongue image database. The different methods of identification like fingerprint, tongue print, facial scans, iris scan and voice recognition which deliver a level of uniqueness and these biometric authentication systems promise their best but are difficult to forge. The study shows that the human tongue can be qualified as a new member of the biometric family. The tongue algorithm study by collecting the points on the tongue gives an efficient template of tongue image and even texture analysis with SIFT (scale invariant feature transform) was useful.¹² Stefanescu et al (2014) have analysed lingual morphological aspects to demonstrate their reliability as main criteria to identify a person in the field of forensic dentistry. The study was conducted with 270 female and male adults with age groups of 21 to 40 yrs. A digital photographic and alginate impression based study was done to analyse the features of the tongue. They were able to categorize the sharp tip tongue in females and septate tip in males. They also specified that geographic and scrotal tongue are features of female subjects.¹³ Zhang & Zhang (2014) have analysed the geometric features of tongue by means of computerized methods and defined them based on traditional chineses

medicine (TCM). The shape of the tongue and its relation to health state was qualitatively analysed using geometry features by means of computerized methods on paper. A total of thirteen geometry features based on distance and area measurements, their ratios were obtained from the tongue image. Based on Traditional Chinese Medicine (TCM), five shapes of the tongue are categorized like rectangle, acute triangle, obtuse triangle, square and circle. The rectangular tongue has a long vertical length and the horizontal width remains constant from root, body and tip. In an acute triangle tongue the vertical length remains longer but the horizontal width reduces or decreases from root, body and tip. An obtuse triangle tongue has its horizontal width greater than vertical length and decreases as it approaches the tip. In the case of square and circular tongue both the vertical length and horizontal width are similar or alike. Classification of the shapes was subsequently carried out with a decision tree. A large data set consisting of 672 images comprising 130 healthy and 542 diseased are tested. The results were effective at shape classification with an average accuracy of 76.2% for all shapes.¹⁴ Musa & Elsheikh (2014) A descriptive cross sectional study was done in Sudan with the population of 50 individuals among them 20 were identical twins (forty individuals) and ten were from the general population. All were free from any tongue lesions and photographs of the tongue were taken and applied with different computer programmes. Each tongue was converted into text, chart and special code generated to compare between them. The length and width of the tongues were found to be more in males when compared to females ($p < 0.05$). They concluded that tongues are different even in identical twins and are to be considered as an identification tool in forensic odontology¹⁵. Radhika & Nithya (2016) have reviewed the studies done on tongue prints and were able to explain its unique features which differ from individual to individual and even between identical twins. Based on the uniqueness of the tongue, variations can be made in males and females. Many modes of biometric systems were found to have their own significance and drawbacks like fingerprint, iris scan and skin color. The review pattern of the study says salient features of tongue are to be considered as tools for identification. The classification of tongue prints with their features were elucidated as follows (Table 1&2).

Jeddy et al (2017) The study sample included twenty participants of which there were 12 males and 08 females and were subjected to visual examination through digital photographs of the dorsal surface of the tongue. The alginate impressions of the dorsal surface of the tongue were taken to make casts by using dental stone. The photographs and casts were analysed for the surface morphology and salient features of the tongue. The study was able to categorize individual people with the features of shape by 3 reference points, texture as fissural depth, number, length and width of tongue. Even sexual dimorphism as an identification method was analysed. The observations of the study were (37.5%) of females with no fissures, central fissures were prominent in both male and females, vertical fissures were common in females, multiple common fissures more in males (33.3%). The fissures were shallow in males and deep were more

common in females. The difference was not statistically significant ($p = 0.064$). The U shaped tongue was 83.3% in males and 75% in females and V shaped was found to be more common in females (25%) than in males (16.7%). Fisher's exact test resulted in $p=0.993$. The study was said to be efficient in considering the tongue print as a biometric authentication tool. The methodology used was simple, easy and can be adopted on a regular basis.¹ Johnson & Gandhi (2018) have undertaken a study on morphological aspects of tongue depicting its role in forensic odontology. The study was conducted on 225 female and male adults between 20 to 50 years and showed a qualitative result among different sex and age groups. They observed 107 individuals (47.5%) had square or rectangular shape. 76 individuals (33.7%) had circular shape and 42 individuals had (18.66%) triangular shape. Most of the individuals had normal texture but few had bifid texture and geographic tongue. They were able to categorize the shape as square, triangular and texture as normal, fissural and quote that physical protection of tongue in mouth is secured and is difficult to forge. The study concluded that lingual impression and photography together are secure methods in forensic odontology.¹⁰

Sreepradha & Vaishali (2019) have conducted a digital photographic study among 100 male and female patients with an age range of 20 to 40 yrs over a period of 3 months.

They categorized female and male subjects as group 1 and group 2. In females U shaped tongues were 32 (64%), V shaped tongues were 11(22%) and bifids were 7 (14%). In males, U shaped tongues were 36 (72%) , V-shaped were 4 (8%) and bifids were 10 (20%). The results of the study were compared and observed as U shaped and bifid tongue were more common in males to V shaped tongue in females. The variation in borders of the tongue was an additional feature among the results. The results and observations of the study showed variation of borders, shape and fissures in male and female patients. They were able to conclude that much more review to be done on the tongue replica.⁵ Venkatesh & Kamat (2019) A preliminary study of tongue prints for biometric authentication was undertaken with an aim to assess the morphological features and variations regarding genders and different ethnicities like Indian, Malay and Chinese. The sample size included 250 participants out of which 81 were Indians, 70 were Malay and 99 were Chinese. An analysis was done using digital photography, shape was more commonly determined as U in men and V in female by considering three reference points from commissure of lip to tip of the tongue. U shaped tongue was more common in males (52.6%) than in females (40.6%). The central fissures were more common on the dorsal surface of the tongue. Shallow fissures on the tongue were found to be more in women than men with deeper ones. Different fissure patterns were determined by displaying many static and dynamic characteristics of the tongue. The level of significance at $p < 0.05$ in terms of shape and texture. They were able to conclude that tongue prints may constitute secure methods for forensic dentistry identification.¹⁶ Abharanalingam & Christopher (2019) have conducted a short study on comparison of lip prints, rugae pattern and tongue prints on

the South Indian population. The sample size was a total of 90 subjects, who were divided into 30 each for palatal rugae, lip and tongue print out of which 15 male and 15 female. The uniqueness of each pattern was highlighted in defining the individuality as an identification tool in the field of forensic odontology. They were able to conclude that vast sample size is essential to prove as an identification tool.⁸ Godbole & Narang (2020) have reviewed a study on tongue scanning as a biometric tool. The dorsal surface of the tongue exhibits a great amount of information along with visual differences in shape, texture and pattern. This review throws light on distinctiveness of tongue prints by using various methods used to extract the features of tongue. The texture features are calculated by SIFT (Scale Invariant Feature Transform) Algorithm which is preprocessed by histogram equalization. The other methods like Dual tree complex wavelet transform (DT-CWT) were used to extract the unique features of tongue (size, shape, textures).⁴

III. METHODOLOGY

The observational study data was collected after obtaining informed consent from the participants as well as patients from the outpatient department of A J Institute of Dental Sciences and hospital, Mangalore. A proper rinsing of the oral cavity is done before the examination with antibacterial solution and the tongue examination carried out. The subjects were asked to protrude 2/3 of their tongue in a relaxed position. A thorough case history was recorded and a detailed clinical examination was performed. A digital photograph of the dorsal surface of the tongue was taken from a predetermined distance using a digital camera and scoring was done based on the following method. **1. Shape** was determined by using 3 reference points (two on right and left commissures of lip and one on tip of the tongue) on digital photography and type of angulation on the tongue. The three reference points were marked with lines using a computer (fig1). An acute angled triangle results which indicates v shaped tongue especially in females. A consent of photography was taken from the participants involved in this clinical study. **2. Texture** like fissure types and its number can be observed and counted by careful clinical examination and digital photography (fig3). A convenient sampling technique was implemented in order to detect the significant difference of 20% in shape and texture of the tongue among male and female, assuming 95% confidence interval, 80% power, the sample size is estimated for the study is a total of 118 individuals wherein 59 male and 59 female are considered for the study.

$$n = \frac{[z_{1-\alpha/2} + z_{1-\beta}]^2 [p_1q_1 + p_2q_2]}{(p_1 - p_2)^2}$$

- *Chi-Square Test* is the statistical technique taken into consideration in finding out the significance of shape and texture in association with the age and sex.

The individuals taken for this study were clinically healthy and had not been exposed to known genotoxic agents and were matched by age and sex. The exclusion criterias were taken into consideration like any kind of developmental disturbances of the tongue and those with preexisting tongue disorders or any systemic illness like hyperthyroidism, gigantism, dwarfism, syphilis, Down syndrome, any contagious diseases and HIV.

The examination of the tongue was carried out by asking the individuals to protract the tongue in a relaxed position to prevent marked contraction of striated lingual muscles. The clinical examination of the tongue was done mainly to observe the morphological features such as shape and texture. The photographs were taken under the suitable environmental and lighting condition. The dorsal surface of the tongue was considered for the view and the best image was captured for the study.¹⁰

Table 1: Classification of Features on Dorsal Surface of Tongue ²

Textural variations in tongue	Shapes of tongue	Tongue geometry features
Tongue fissure or tongue crack	Elliptical	Length
Smooth tongue	Hammer	Width
	Rectangular	Thickness
	Acute triangular	
	Obtuse triangular	
	Square	
	Round	

Table 2: Classification of Tongue Features by Stefanescu et al. ^{2,13}

Tongue Texture	Shapes Of Tongue	Longitudinal Grooves	Lingual Apex
Physiological	Ovoid	Perceptible/imperceptible	Sharp
Scrotal	Ellipsoid	Rectilinear/twisty	Septate
Geographic	Rectangular	Superficial/deep	
	Pentagonal		
	Trapezoidal to asymmetrical		

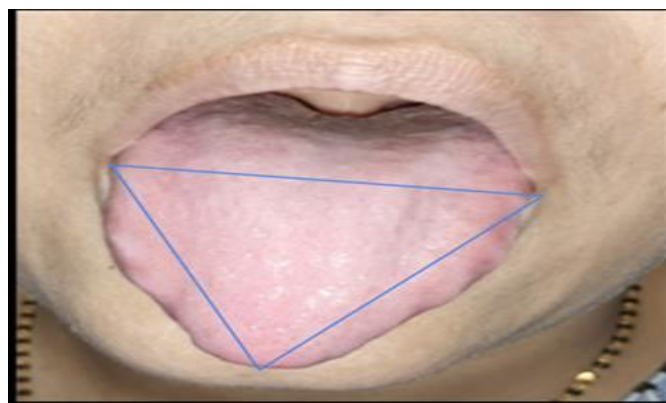
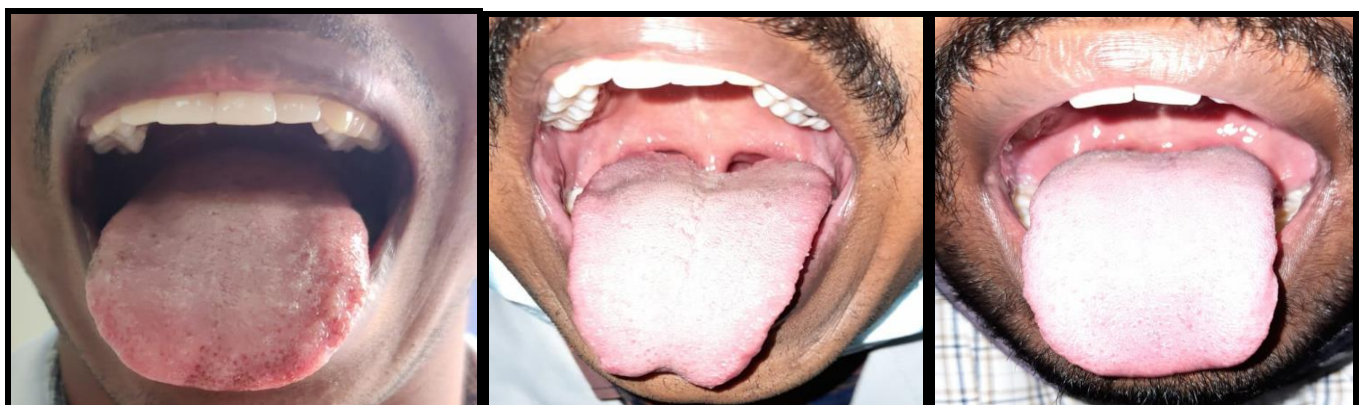


Fig 1: V-Shaped Female Tongue with Three Reference Points



(a) Elliptical Tongue, Male (U-shape)

(b) Bifid tongue, Male

(c) Rectangular Tongue, Male



(d) Circular Tongue, Male

(e) Square Tongue, Male

(f) Triangular Tongue, (V-shape)



(g) V- shape Tongue, Female

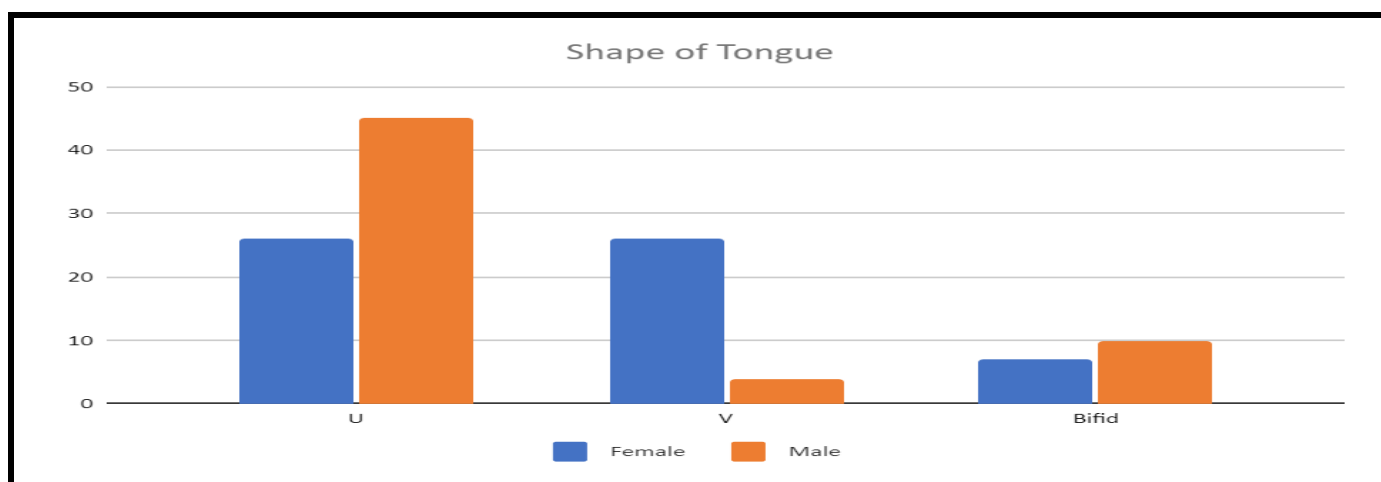
(h) Geographic Tongue, Female

(i) U- shape Tongue, Female

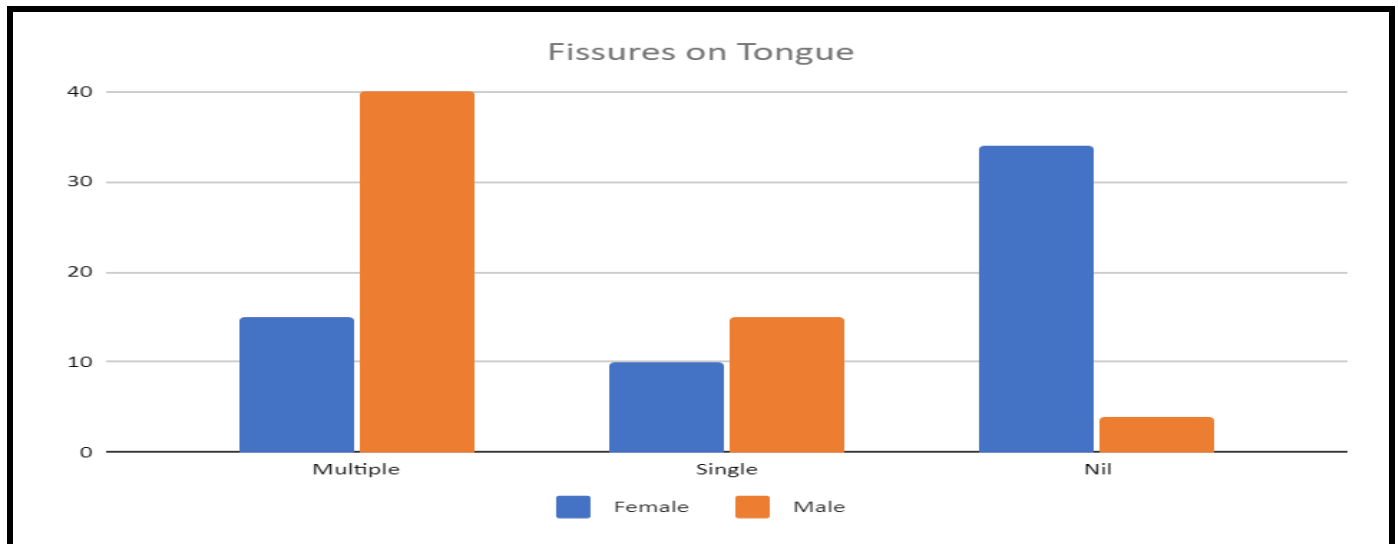
Fig 2(a-i): Different Shapes of the Tongue



Fig 3: Male & Female Tongue with different Types of Fissures - Single, Multiple & Nil



Graph 1: Shape Observed in the Study Subjects



Graph 2: Fissures Observed in the Study Subjects

Table 3: Shape Observed in the Study Subjects

Shape of Tongue	Female	Male	Total
U	26	45	71
V	26	4	30
Bifid	7	10	17
Total	59	59	118

Table 4: Fissures Observed in the Study Subjects

Fissures on Tongue	Female	Male	Total
Multiple	15	40	55
Single	10	15	25
Nil	34	4	38
Total	59	59	118

IV. RESULTS & OBSERVATIONS

This clinical study was designed to examine and categorize the variations in morphological characteristics of the tongue as observed on digital photographs to know its reliability and to assess the usefulness of tongue print for personal identification in forensic science. The morphological characteristics of the tongue like the shape and texture were to be considered after observing the photographs.

The study was performed on 118 individuals inclusive of 59 male and 59 female with an age range of 20 to 45 years (graph 1&2). The data were collected, tabulated and subjected to statistical analysis. Out of 118 subjects, male gender showed U-shaped tongue in 45 subjects, bifid tongue in 10 subjects (fig 2), whereas V shaped tongue in 04 subjects. In female gender, U shaped tongue was noticed in 26 subjects, bifid tongue was noticed in 07 subjects, whereas V shaped acute triangle tongue (fig 1) was observed in 26 subjects. The association between the shape of the tongue and gender was statistically significant ($P < 0.05$). Out of 118 subjects, male gender showed multiple fissures on tongue (fig 3) in 40 subjects, single fissure in 15 subjects, whereas no fissures in 04 subjects. In female gender, multiple fissures on tongue was noticed in 15 subjects, single fissure was noticed in 10

subjects, whereas no fissures was observed in 34 subjects. The association between the fissure of the tongue and gender was statistically significant ($P < 0.05$).

Considering a confidence interval of 95% there is a statistically significant correlation between the shape of the tongue and the gender and fissures and gender. From this dataset we can conclude that Critical value is lower than the chi square score. Thus there is a significant relationship between 1) Gender and shape 2) Gender and fissures. U shaped tongue is most likely to be found in males, V shaped tongue is most likely found in females and there is a significant statistical correlation (It is very unlikely to find a male with a V shaped tongue). Multiple fissures are most likely to be found in males, No fissures are most likely found in females and there is a significant statistical correlation (It is very unlikely to find a male with no fissures on their tongue) From a forensic perspective if a tongue has been found having V shape and no fissures it is very likely that the person is a female. However the sample set is very small and to be deemed useful for a forensic investigation these hypotheses need to be tested on larger datasets.

V. DISCUSSION

No biometric has yet been developed that is perfectly reliable and secure. The present systems like finger and palm prints are usually frayed or destroyed. Signatures, voice and hand shapes and images of iris are easily forged. Face recognition can be made difficult by occlusions or face lifts, and biometrics such as fingerprints, iris, and face recognition are susceptible to spoofing attacks¹⁷. Tongue print being a unique biometric tool has its advantages over other systems like genetic independence as no two tongues are similar, physical protection being well protected by oral cavity and stability over time and cannot be easily forged¹⁸. A study by Diwakar and Maharshi, have expressed that the tongue can be a reliable member of the biometrics family¹². Tongue biometric systems with visual cryptography technique and its application in public use at banking systems using 3D databases has been proposed by Naaz et al¹⁹. Tongue scanners are under research and being tested, as it's an ongoing study which recently proposed by Bade et al as tongue recognition systems are based on 2D dual-tree complex wavelet transforms.²⁰

In the present study out of a total 118 subjects, male subjects were 59 and female subjects were 59. The age range taken into consideration was 20-45 years because individuals at this age group are devoid of any major systemic illness such as diabetes, and anaemia, which can contribute to morphological changes on the surface of the tongue. Even as the age advances other illnesses may affect the morphological features of the tongue and hence an age group between 20 and 45 years was selected for the clinical study. We have excluded patients under 20 years because the changes in the tongue morphology at this age group are unlikely as the supporting studies were almost of the same age range^{5,10,13}.

A. Shape of the Tongue

Based on Traditional Chinese Medicine (TCM), five shapes of the tongue like rectangle, acute triangle, obtuse triangle, square and circle (fig 1&2). The rectangular tongue has a long vertical length and the horizontal width remains constant from root, body and tip. In an acute triangle tongue the vertical length remains longer but the horizontal width reduces or decreases from root, body and tip. An obtuse triangle tongue has its horizontal width greater than vertical length and decreases as it approaches the tip. In case of square and circular tongue both the vertical length and horizontal width are similar or alike.¹⁴

In the present study, we could observe different shapes of the tongue but again narrowed mainly into U, V shaped tongue and Bifid tongue. Out of 118 subjects, the U shaped tongue was found to be more in case male subjects than V shaped tongue in males. V-shaped tongue was observed to be slightly rarer in male subjects. Bifid tongue was noticed to be slightly higher in case of male subjects than in female subjects. U shape was more common in males compared to females. V shaped acute triangle tongue was more common in females compared to males. The association between the shape of tongue and gender was statistically significant ($P <$

0.05). These observations were in agreement with the findings of other studies by Jeddy et al, Sreeprada C and Venkatesh. Further they were able to classify the different shapes of the tongue like rectangular, hammer, ellipsoid, pentagonal and trapezoidal etc. The reason for the V-shaped tongue in females could be smaller mandible size in females compared to males.^{13,7} Borders of the tongue were also considered as observations under the study carried out by Sreeprada and Vaishali but these findings were very minimal and not included in our study⁵. Abraham and Binita were able to observe and categorize different shapes of the tongue but as the sample size was small and found to be less significant. A similar effort was done in our study to categorize based on the different shapes of the tongue but due to small sample size, not considered under the criteria¹⁰. A preliminary study on tongue by Venkatesh and Kamat has shown the methodology using 3 reference points on tongue. The results of the studies by Jeddy et al, Sreeprada C and Venkatesh SB reflect much similarity with our study in concluding U shape is more common in male and V shape in female even in different populations and ethnicity^{1,5,16}.

B. Fissures of the Tongue

Fissures on the surface of the tongue vary in terms of number and location like central, vertical, horizontal, single, multiple or absent. Fissures were categorized as absence of fissure, single fissure and multiple fissures. In the present study multiple fissures were found to be predominant in male subjects than female subjects, single fissures on the surface of the tongue were slightly at a higher side in male subjects. Absence of fissures were observed to be more on the surface of the female tongue in comparison with the male tongue. The association between gender and fissures was found to be statistically significant as $p < 0.05$. Present study with these observations were consistent with the studies by Jeddy et al and Sreeprada. Fissures were found to be more common on the dorsal surface of the tongue in males. According to the studies by Venkatesh and Kamat, the central fissures were more common on the dorsal surface of the tongue. Shallow fissures on the tongue were found to be more in women than men with deeper ones. Different fissure patterns were determined by displaying many static and dynamic characteristics of the tongue. Fissures were found to be less, single or nil and shallow in females than males in our study¹⁶.

VI. CONCLUSION

Tongue replica for personal identification has emerged as a newer method but with limited studies in comparison with other biometric methods. This clinical study of tongue features represents its variations with respect to each individual and the photographic images of the tongue can enhance personal identification with other techniques in forensic science and could serve as a database as well as a guide for personal identification purposes.⁵ The static and dynamic characteristics of the tongue are unique for every individual even on consideration with gender and ethnicity. A large sample size should be necessary to determine the common morphological features. A debate cannot be carried out as compared with other studies and authors a more ample

research like the lingual impression, together with its photographic image, may constitute secure methods in addition to rugoscopy and cheiloscopy in forensic odontology. The significant details from the dorsal aspect of the tongue and its further studies have to be updated. It has been specified that geographic and scrotal tongue are considered to be characteristic features to female subjects and also as stand point to sexual dimorphism. A further note on classification of the tongue based on the anatomic aspects and morphological features using reference points have to be reviewed.¹³ The tongue print along with dental evidence obtained from the oral cavity can help in identification and provide information needed in legal process as it is a real proof of life with genetic independence.¹⁰ Dentists can adopt the procedure of lingual impression as a chairside technique and large scale studies are needed to differentiate between genders and to create a database. Dental records can play an important role and to conclude tongue print being a unique record which cannot be forged and can be used for identification purposes.⁶

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