

Original Research

Tongue print as a valuable biometric and forensic tool: A digital photographic study.

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Abstract

Background: Surface features present on the dorsal surface of the tongue along with colour and shape are unique characteristics of every individual. Tongue print is being considered as a new biometric and forensic authentication tool. This digital photographic study was conducted to analyze and compare morphological differences on the dorsal surface of the tongue which can serve as a valuable tool in forensic odontology.

Methodology: The present study utilized a digital photographic method. Patients who visited the outpatient department (OPD) of the dental institution for availing necessary dental treatment were included in the study. The final study sample comprised 316 subjects which were recruited by systematic random sampling. The shape, surface texture, colour etc. of the tongue were recorded. Descriptive statistics and chi-square tests were used for statistical analysis. Significance was set at $p \leq 0.05$.

Results: The majority of the subjects (60.13%) had a 'U-shaped' tongue. 'Tongue fissures/cracks' and 'Smooth Tongue' were the two prominent surface textures present among 59.18% and 35.13% of the study subjects respectively. The shape and surface texture of the tongue were significantly associated with the gender of the study subjects. Non-visibility of median septum was found more among females than males. More than two-thirds of the subjects (77.51%) belonging to the age group of 18-30 years had pink-coloured tongues and the findings were highly significant ($p=0.00$).

Conclusion: In addition to rugoscopy and cheiloscopy, the study of lingual morphology may be one of the secure methods for identification in forensic dentistry.

Keywords: Tongue; Gender Identity; Health Status; Diagnosis.

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Introduction

Tongue Print or Lingual Print or Impression is a new biometric authentication method that has the potential to be widely used in forensics.^[1-3] The shape and texture of the exposed portion of the tongue carry some unique information that is called ‘Tongue Print.’ As the tongue is enclosed in the oral cavity, it is well protected from the external environment.^[4] It is a vital organ and Traditional Chinese Medicine (TCM) has described its vitality as “Tongue of life” where it appears in vital colour. In contrast, due to its dark and withered appearance, it is termed the “Tongue of Death” in TCM. Moreover, since the tongue is an internal organ, it provides substantial proof of whether the person is alive or not.^[5] The tongue also provides valuable information regarding the health status of a person and it can be a useful tool in diagnosing underlying medical conditions.^[6] The geometric shape of the tongue usually remains constant, and the physiological surface texture remains unaltered even if there are changes in the tongue coating.

Being enclosed in the oral cavity, the tongue is well protected from environmental influences and therefore imprints obtained from the tongue are very difficult to manipulate or forge, unlike other identification tools.^[6] The uniqueness of the tongue print is that no two tongues are similar, and there is no resemblance between the tongues of identical twins. Static and dynamic features of the tongue are therefore also useful for authentication of identity.^[6] The human tongue delivers a level of uniqueness in shape and texture which cannot be changed this makes it a probable suitable tool for use in forensic identification and biometric authentication. The use of tongue-based identification system is still at the grassroots level in India, so more research evidence and planning are needed for its implementation. Dental professionals can therefore play an important role in making tongue prints a widely available and acceptable tool.

Visual inspection, digital photography and lingual impression techniques can be used to assess the credentials of the tongue. The tongue's genetic independence, physical protection and its stability over time offer tongue prints significant advantages over other biometric systems.^[7] Therefore, this study was conducted to analyze and compare morphological differences on the dorsal surface of the tongue with the aim of contributing evidence for the probable utilization of the tongue as a valuable tool in forensic identification using digital photography.

Methodology

Ethical clearance and informed consent

Ethical clearance for conducting the study was taken from the institutional ethics committee (Ref no. DAV/DCH/425 dated 04-08-2022) before starting the study. The methodology of the study was also well explained to each subject, and they were assured of data confidentiality. Informed consent was taken from the study subjects after explaining the purpose of the study to them.

Study population and study sample.

Patients who visited the Outpatient department (OPD) of the dental college to seek dental treatment were included in the study and formed the study sample. The sample size was estimated by using the below-mentioned formula-

$$n = Z^2 p (1 - p) / d^2$$

n = sample size, z = level of confidence 95% = 1.96, p = expected highest Prevalence 71%, d= Precision (5% = 0.05).

With an attrition rate of 5%, the sample size calculated was 302. A total of 316 subjects constituted the final sample size which was recruited by systematic random sampling methodology. Exclusions from the study criteria included patients with a history of any systemic illness, smokers, tongue deformity, patients

suffering from any debilitating chronic disease and those subjects who did not give their consent to participate in the study.

Examination

The pictures of the dorsal surface of the tongue were taken. Data was recorded on a Google form which included demographic characteristics of the study subjects (age, gender etc.) and the details of the surface of the tongue (morphological characteristics like geographical shape, surface texture details, colour, apex and visibility of medial septum). The pictures were taken under the same environmental and lighting conditions and from a predetermined distance using a professional camera (Nikon D5200) using a tripod wherever necessary. Before the clinical examination of the tongue, the patients were asked to rinse and clean the tongue gently with water to remove any surface debris or food particles. Also, patients were told to protract their tongue in a relaxed position to avoid contraction of the striated lingual muscle fibers which could bring alteration in the characteristic aspects, as well as the shape of the tongue. Calibration of the examiners was done to achieve intra-examiner reliability and reproducibility. Two examiners evaluated the images independently prior to the investigation. Photographs were taken after clinical examination and digitally analyzed.

Statistical Analysis

The observed data was tabulated and assessed using the SPSS statistical package (SPSS, version 21.0, Chicago, IL, USA). Numbers and percentages were used to do calculations regarding categorical measurements. The Chi-square test was used to analyze the prevalence of various aspects of tongue morphology with respect to the age and gender of the study group. The significance level was set at $p \leq 0.05$.

Results

Socio-demographic profile

Among 316 subjects who took part in the study, most of the subjects (60.7%) were females as compared to males (39.2 %). Also, a vast majority of the subjects (79%) were less than 30 years of age and 21% of the subjects were older than 31 years. Subjects whose place of residence was rural were more as compared to the subjects residing in urban areas. Details are in Table 1.

Table 1: Socio-demographic profile of the study population

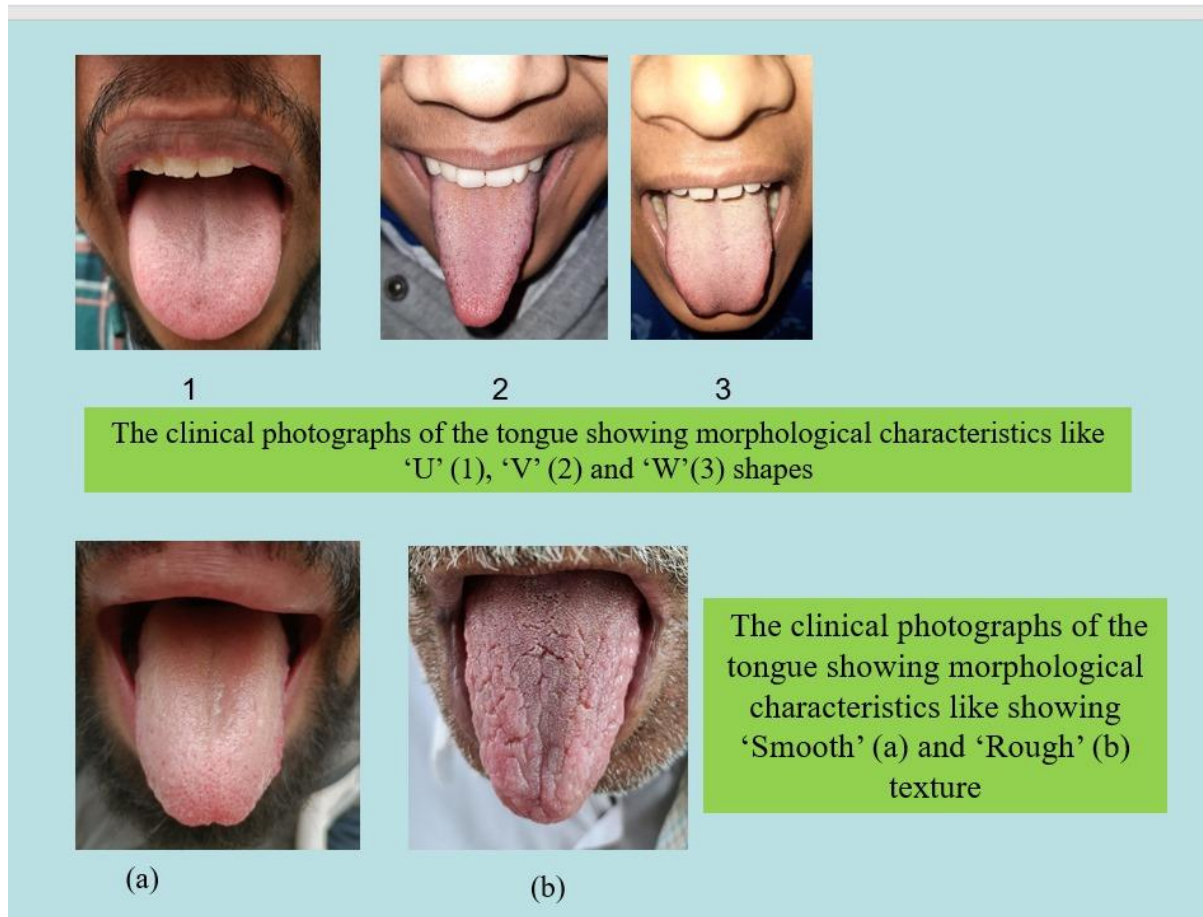
Demographic profile		Number	Percentage
Gender	Male	123	39.3
	Female	193	60.7
Age Group (in years)	18-30	249	79
	>30	67	21
Place of Residence	Urban (City & Town)	134	42.5
	Rural (Village)	182	57.

Morphological characteristics of tongue

Based on Gender

The majority of the subjects (60.13%) had a 'U shaped' tongue and only (6.65%) of subjects had an 'Asymmetrical' tongue (Figure 1).

Figure 1: Showing various shapes and texture of the tongue.



A greater percentage of females (60.94%) reported having 'U-shaped' and 'V-shaped' tongues as compared to males. 'Tongue fissures/cracks' and 'Smooth Tongue' were the two prominent surface textures present among 59.18% and 35.13% of the study subjects respectively (Table 2). Results of the chi-square test showed that the gender of the subjects was significantly associated with the shape and surface texture of the tongue ($p < 0.05$). 'Bifid tongue' was present in only 0.95% of study subjects. Median septum was not visible in approximately 69% of subjects and this finding was more pronounced in females as compared to males. The tongue appeared pink in colour in nearly two-thirds of the subjects (72.47%) and pinkish purple in 3.8% of subjects

Table 2: Association of morphological characteristics of the tongue with gender

Gender	Shape					Total	p-value
	Asymmetrical	U Shape	V Shape	W Shape			
Female	10 (5.21%)	117 (60.94%)	52 (27.08%)	13 (6.77%)	192 (60.75%)	0.016*	
Male	11 (8.87%)	73 (58.87%)	21 (16.94%)	19 (15.32%)	124 (39.24%)		
Total	21 (6.64%)	190 (60.13%)	73 (23.1%)	32 (10.13%)	316 (100%)		
Surface texture							
	Bifid tongue	Geographic	Plaque	Smooth Tongue	Tongue fissures/cracks	Total	p-value
Female	1 (0.52%)	2 (1.04%)	4 (2.08%)	84 (43.75%)	101 (52.6%)	192 (60.75%)	0.001* (HS)
Male	2 (1.61%)	2 (1.61%)	7 (5.65%)	27 (21.77%)	86 (69.35%)	124 (39.24%)	
Total	3 (0.95%)	4 (1.26%)	11 (3.48%)	111 (35.13%)	187 (59.18%)	316 (100%)	
Median septum							
	Not visible	Visible	Total				p-value
Female	138 (71.88%)	54 (28.13%)	192 (60.75%)				0.137
Male	79 (63.71%)	45 (36.29%)	124 (39.24%)				
Total	217 (68.67%)	99 (38.33%)	316 (100%)				
The apex of the tongue							
	Pointed	Round	Septate	Total			p-value
Female	50 (26.04%)	133 (69.27%)	9 (4.69%)	192 (60.75%)	0.077		
Male	27 (21.77%)	83 (66.94%)	14 (11.29%)	124 (39.24%)			
Total	77 (7.28%)	216 (68.35%)	23 (24.37%)	316 (100%)			
Colour							
	Pale pink	Pink	Pinkish purple	Total			p-value
Female	41 (21.35%)	144 (75%)	7 (3.65%)	192 (60.75%)	0.443		
Male	34 (27.42%)	85 (68.55%)	5 (4.03%)	124 (39.24%)			
Total	75 (23.73%)	229 (72.47%)	12 (3.80%)	316 (100%)			

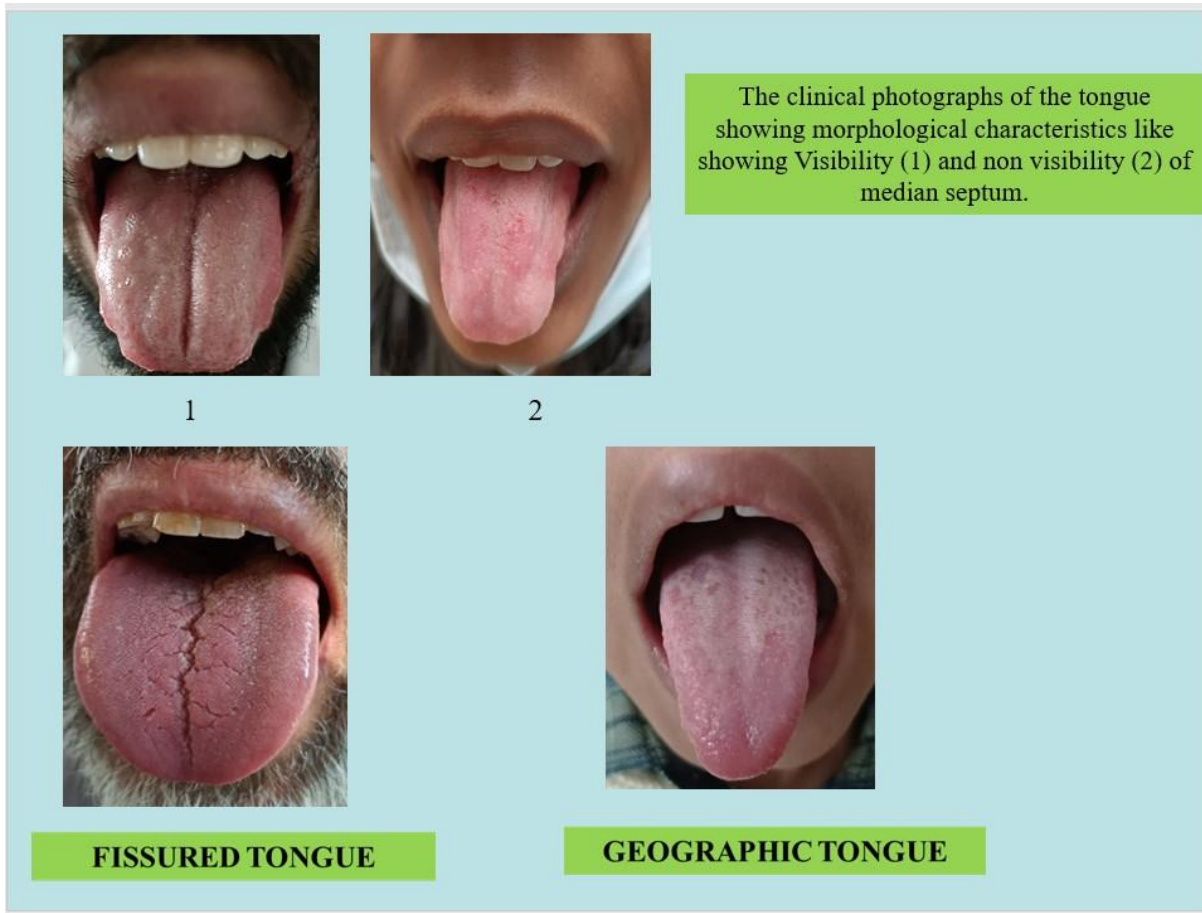
Test used- Chi-square test, *p≤0.05, statistically significant, HS- highly significant

However, there was no significant association of gender with the colour, apex and median septum of the tongue (p>0.05).

Based on Age-group

Approximately 60% of subjects in both age groups had U-shaped tongues. Tongue fissures/cracks were reported in 61.19% of subjects belonging to the age group of more than 30 years. Median septum was visible only in 32.53% of subjects belonging to the age group of 18-30 years.

Figure 2: Showing visibility of the median septum, fissured tongue, and geographic tongue



Digital photographs also revealed that the apex of the tongue was round in more than 65% of subjects in both the age-groups. More than two-thirds of the subjects (77.51%) belonging to the age group of 18-30 years had pink-colored tongues and the findings were highly significant ($p=0.00$). However, the age group of the subjects had no bearing on the other morphological characteristic features of the tongue ($p>0.05$)

Table 3: Association of morphological characteristics of the tongue with age-groups

Agegroup (in years)	Shape					Total	p-value
	Asymmetrical	U Shape	V Shape	W Shape			
18-30							
More than 30	15 (6.02%)	150 (60.24%)	60 (24.1%)	24 (9.64%)	249 (78.8%)		0.69
Total	6 (8.96%)	40 (59.7%)	13 (19.4%)	8 (11.94%)	67 (21.2%)		
	21 (6.64%)	190 (60.13%)	73 (23.1%)	32 (10.13%)	316 (100%)		
Surface texture							
	Bifid tongue	Geographic	Plaquet	Smooth Tongue	Tongue fissures/cracks	Total	p-value
18-30	3 (1.2%)	2 (0.8%)	7 (2.81%)	91 (36.55%)	146 (58.63%)	249 (78.8%)	
More than 30	0 (0.0%)	2 (2.99%)	4 (5.97%)	20 (29.85%)	41 (61.19%)	67 (21.2%)	0.283
Total	3 (0.95%)	4 (1.26%)	11 (3.48%)	111 (35.13%)	187 (59.18%)	316 (100%)	
	Median septum						
	Not visible	Visible	Total				p-value
18-30	168 (67.47%)	81 (32.53%)	249 (78.8%)				
More than 30	49 (73.13%)	18 (26.87%)	67 (21.2%)				0.375
Total	217 (68.67%)	99 (38.33%)	316 (100%)				
	The apex of the tongue						
	Pointed	Round	Septate	Total			p-value
18-30	64 (25.7%)	170 (68.27%)	15 (6.02%)	249 (78.8%)			0.183
More than 30	13 (19.4%)	46 (68.66%)	8 (11.94%)	67 (21.2%)			
Total	77 (7.28%)	216 (68.35%)	23 (24.37%)	316 (100%)			
	Colour						
	Pale pink	Pink	Pinkish purple	Total			p-value
18-30	45 (18.07%)	193 (77.51%)	11 (4.42%)	249 (78.8%)			0.00* (HS)
More than 30	30 (44.78%)	36 (53.73%)	1 (1.49%)	67 (21.2%)			
Total	75 (23.73%)	229 (72.47%)	12 (3.80%)	316 (100%)			

The test used- Chi-square test, *p≤0.05, statistically highly significant (HS)

Discussion

There is substantial evidence from multiple studies that have validated the use of tongue print as a valuable tool for diagnostic and verification purposes.^[8-11] Many previous as well as our study provide ample proof for recognizing the tongue to be very efficient in human identification. Despite many studies that have been conducted on the tongue and its use in forensics, it remains unexplored to its full potential. The secondary of purpose this study was improve awareness among forensic experts (forensic dentists) and other scientists on the important use of tongue prints in human identification especially in unusual or emergency situations like natural or man-made disasters.

The dorsal surface morphology, texture, and geometrical shape reveal vital details about an individual's health and oral hygiene. Careful inspection and analysis of the tongue provides us with vital information regarding an individual's identity thereby making it an efficient tool for identification. Details collected from tongue inspection provide us with precise information regarding the person's health.^[8] As it is located inside the oral cavity, it is protected in a dead person.^[9] The morphology of the tongue varies among gender, race, and ethnicity.^[10] This makes it an important biometric tool.

Sexual dimorphism in the tongue has an important role to play in human identification. In the present study, the commonly found tongue was U-shaped (60%) followed by V-shaped (23%). The present study revealed that a U-shaped tongue was more common in males (58.9%) and a V-shaped tongue was found more in females (16.5 %). Other studies also revealed similar results.^[11,12] The prevalence of a V-shaped tongue in females may be due to the smaller mandible in females also the W-shaped tongue was more evident in males.^[13-15] Septate tongue was present among 23 subjects in the study, and it was observed more in males. Developmental disturbances occurring in the anterior two-thirds region of the tongue are largely responsible for this occurrence.^[16] Fissured tongue is a benign, asymptomatic condition of unknown etiology. This could be due to a polygenic or autosomal dominant gene. It is usually observed in the general population of both genders.^[17] The present study demonstrated the presence of fissures on the tongue was more commonly found in males as compared to females. This finding is in congruence with some other studies conducted in different regions where the prevalence of fissured tongue was reported more in the case of males as compared to females.^[18]

In our study, the colour of the tongue varied both based on age and gender. The tongue appeared pink in colour in nearly two-thirds of the subjects (72.47%) and pinkish purple in 3.8% of subjects. Surendra et al in their study reported the prevalence of pale color tongue in 76.7% of subjects and pink colour in 16.7% of subjects.^[18] Astekar et al in their study reported whitish-colored tongue in 80% of the subjects, and pale pink in 14%.^[15] However, in the present study majority of participants had pink-colored tongues (72.4 %). The difference might be due to the varying sample size and study population.

Different methods such as visual inspection method, photography method, impression method, and ultrasound are used to study the morphology of the tongue.^[19] In this study, only visual inspection and photography methods were used. The age of the subjects had no bearing on morphological characteristics of the tongue except colour in our study.

It is very evident from our study and similar studies that because of the unique characteristics, just like iris patterns and fingerprints, tongue prints might serve as an identification tool. The implementation of a tongue recognition system with sensors in terms of advancing personal identification and authorization processes for enhanced security may also prove to be quite beneficial.

Conclusion

The majority of the subjects had a 'U' shaped tongue. The gender of the subjects was significantly associated with the shape and surface texture of the tongue. The apex of the tongue was round in more than 65% of subjects in both the age-groups. The exploration and utilization of tongue-prints as a biometric identifier is pivotal in the field of forensic dentistry. Creating a comprehensive database and building and implementing a tongue recognition system are considered vital in advancing the use of tongue-prints for personal identification and security. However, there are limitations to the applicability of the study results as they will be more useful in profiling rather than outright identification. Further research, standardization efforts, and consideration of privacy and ethical concerns are essential steps in overcoming challenges related to data collection.

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