Tongue prints in biometric authentication: A pilot study

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Abstract

Background and Objectives: Biometric authentication is an important process for the identification and verification of individuals for security purposes. There are many biometric systems that are currently in use and also being researched. Tongue print is a new biometric authentication tool that is unique and cannot be easily forged because no two tongue prints are similar. The present study aims to evaluate the common morphological features of the tongue and its variations in males and females. The usefulness of alginate impression and dental cast in obtaining the lingual impression was also evaluated.

Materials and Methods: The study sample included twenty participants. The participants were subjected to visual examination following which digital photographs of the dorsal surface of the tongue were taken. Alginate impressions of the tongue were made, and casts were prepared using dental stone. The photographs and the casts were analyzed by two observers separately for the surface morphology including shape, presence or absence of fissures and its pattern of distribution. Three reference points were considered to determine the shape of the tongue.

Results: The most common morphological feature on the dorsum of the tongue was the presence of central fissures. Multiple vertical fissures were observed in males whereas single vertical fissure was a common finding in females. The fissures were predominantly shallow in males and deep in females. The tongue was predominantly U shaped in males and females. V-shaped tongue was observed in 25% of females.

Conclusion: Tongue prints are useful in biometric authentication. The methodology used in the study is simple, easy and can be adopted by dentists on a regular basis. However, large-scale studies are required to validate the results and also identify other features of the tongue that can be used in forensics and biometric authentication process.

Keywords: Authentication, biometric, fissures, forensic, tongue prints, tongue shape

INTRODUCTION

Biometrics refers to a real-time identification system that is used in the identification of a person using a specific physical or behavioral characteristic which is compared with a library of characteristics of many other people.[1] This is done using a biometric scanning device (tongue-print scan) which captures the user's biometric data such as the tongue-print scan and converts it into a digital information that the computer interprets and verifies. There is a higher level of assurance in this type of identification process.[2] Tongue print is the information carried on the exposed portion of the tongue that is the shape and texture put together. The geometric shape of the tongue is usually constant, and the physiological surface texture does not

vary a lot.[3] Tongue is an organ that can be easily exposed for inspection but at the same time well protected from environmental influences and therefore very difficult to manipulate or forge unlike other identification systems.[4]

The uniqueness of the tongue print is that no two tongues are the same, and studies have found that the tongue of identical twins also does not resemble each other.[5] The tongue provides both static and dynamic features for authentication.[6] Therefore, the use of tongue prints as a biometric authentication system is gaining a lot of momentum. In the past 10 years, research has been targeted towards developing a tongue print recognition system, and the first of its kind was proposed by Liu *et al.* in 2007.[1] Recently, tongue recognition systems based on 2D dual-tree complex wavelet transform have been proposed by Bade *et al.*[7] Tongue scanners are under research and being tested.[8]

In India, this system of identification is still in the grassroot level and needs more quantum of research and planning to implement the same. Creation of a database is pivotal for identification, but there is no national database available currently in India. Furthermore, there is no scanning device yet been created for capturing the tongue print. Visual inspection and digital photography have been the time-tested methods that have been adopted so far. Lingual impression is the impression of the dorsal surface of the tongue along with the lateral borders. This will be useful in determining the shape and the surface characteristics of the tongue and can serve as a permanent record through the cast.

A small-scale study was carried out in our institution with the aim of determining the most common tongue features, its predominant shape and variations in males and females. Further, the usefulness of alginate impressions and dental cast as a permanent record of the lingual impression was also evaluated. The sexual dimorphism in the features of the tongue was studied.

MATERIALS AND METHODS

The study participants were selected on a random basis from patients attending the Outpatient Department of Oral Medicine and Radiology, Thai Moogambigai Dental College. Patients with habit of smoking and any systemic illness were excluded from the study. After obtaining informed consent, clinical examination of the patient's tongue was performed. Before the examination, the patients were asked to rinse the mouth gently with water to remove any surface debris or food particles. A total

of twenty patients were part of the study. Subsequent to clinical examination, photographs (front and side view) were taken from a predetermined distance using a digital camera (7 megapixels). Alginate impression of the dorsal surface of the tongue was made, and a positive replica was prepared using Type II dental stone [Figure 1a and b]. The photographs and the cast were analyzed and compared for morphological features such as shape and characteristics of fissures by two independent observers. Three reference points were considered to determine the shape of the tongue. The reference points included the region of the tongue in contact with the commissure of the lips (when protruded outside the mouth) and the tip of the tongue [Figure 2a and b].
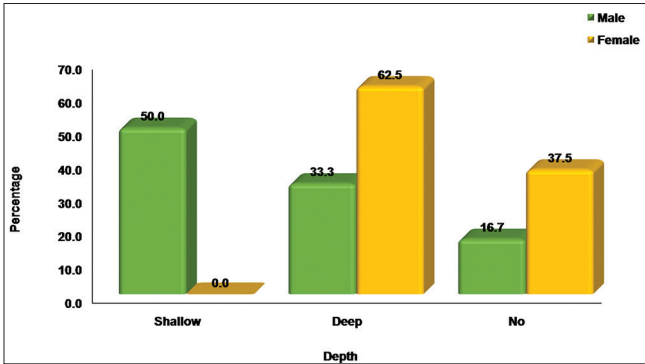
RESULTS

A total of 20 patients participated in the study, of which there were 12 males and 8 females. Fissures were the most common surface textural characteristic that was observed in the participants. Fissures were not observed in 37.5% of females [Table 1]. Central fissures were predominant in both males and females. When considering the direction and the number of fissures, it was observed that the presence of vertical fissure was more common in females and multiple vertical fissures were more common in males (33.3%) [Figure 3]. The next characteristic that was taken into account was the depth of the fissure. They were categorized as either shallow or deep based on visual inspection. It was observed that fissures were shallow in males (50%) and deep fissures were common in females (62.5%) [Figure 4]. The difference was not statistically significant [$P = 0.064$, Table 2]. On analyzing the shape of the tongue, it was found that the most common shape was U shape in both males and females (83.3% and 75%, respectively) followed by V shape which was more common in females than males (25% and
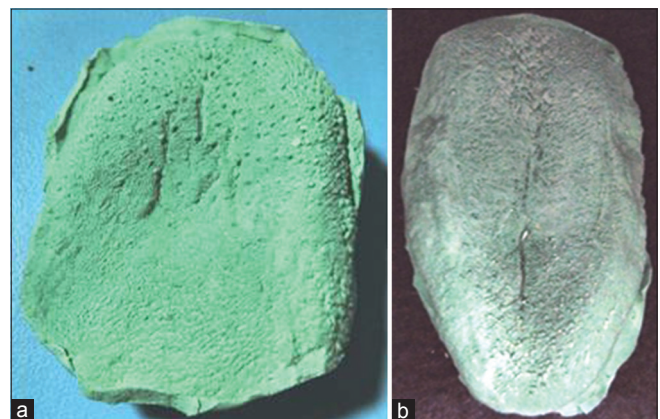
Figure 1: (a and b) Stone casts of tongue prints
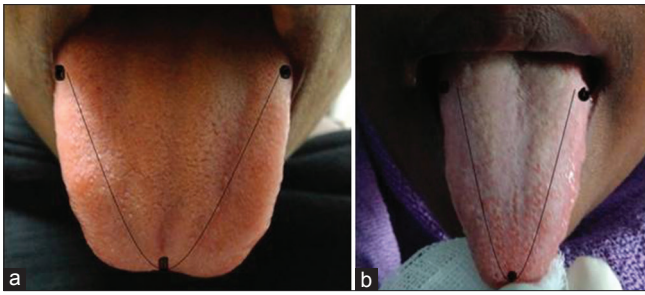
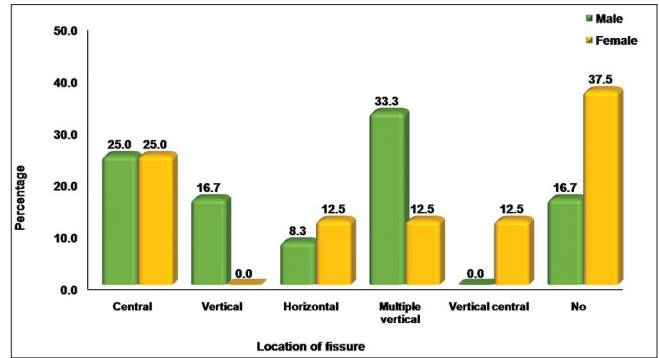**Figure 2:** (a and b) Reference points for determining the shape of the tongue

Figure 3: Gender-wise distribution of location of fissure

Figure 4: Gender-wise distribution of depth of fissure

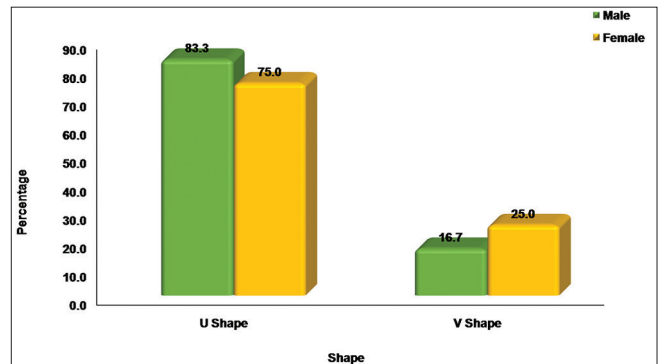**Figure 5:** Gender-wise distribution of the shape of the tongue

16.7%, respectively) [Figure 5]. Fisher's exact test resulted in a $P = 0.993$, which was not statistically significant [Table 3]. Analysis using photographs and stone casts revealed 90% matching validating alginate as a reliable aid in obtaining lingual impressions.

DISCUSSION

Identity fraud is a serious threat to society. Innovative and efficient identification systems are an urgent need to combat this social issue. Identification of human beings based on characteristic physiological parameters is the central dogma of biometric authentication and information security. Verification and authentication are two main functions of any biometric tool.[9] Tongue print is a unique biometric tool which cannot be forged easily. Advantages of tongue prints over other biometric systems are genetic independence (no two tongue are similar), physical protection (well encased in the oral cavity) and its stability over time.[4] Research on tongue prints is at a preliminary stage. A study by Diwakar and Maharshi reported tongue as a reliable member of biometrics family.[2] Application of tongue biometrics system in public-use system such as banking system has been proved by Naaz *et al.* in 2011.[4] A recent study has validated the use of tongue prints in forensic identification. The study also proposed the use of alginate impression in obtaining lingual impression as an efficient technique.[10] Implications of tongue prints and

Table 1: Gender-wise distribution of the location of the fissures

Location of fissure	Gender		Fisher's exact test (*P*)
	Male, *n* (%)	Female, *n* (%)	
Central	3 (25.0)	2 (25.0)	0.698
Vertical	2 (16.7)	0	
Horizontal	1 (8.3)	1 (12.5)	
Multiple vertical	4 (33.3)	1 (12.5)	
Vertical central	0	1 (12.5)	
No	2 (16.7)	3 (37.5)	
Total	12 (100)	8 (100)	

Table 2: Gender-wise distribution of the depth of the fissures

Depth	Gender		Fisher's exact test
	Male, *n* (%)	Female, *n* (%)	
Shallow	6 (50.0)	0	0.064
Deep	4 (33.3)	5 (62.5)	
No	2 (16.7)	3 (37.5)	
Total	12 (100)	8 (100)	

Table 3: Gender-wise distribution of the shape of the tongue

Shape	Gender		Fisher's exact test
	Male, *n* (%)	Female, *n* (%)	
U shape	10 (83.3)	6 (75.0)	0.993
V shape	2 (16.7)	2 (25.0)	
Total	12 (100)	8 (100)	

its use as a forensic tool remain unexplored in the field of dentistry. To the best of our knowledge, the present study is a novel attempt and first of its kind.

The presence of fissures was the most common morphological characteristic seen in the dorsum of the tongue. The fissures were predominantly located in the central region of the tongue as observed by Stefanescu *et al*.[10] The predominant shape of the tongue in both males and females was "U shape." V-shaped tongue with a sharp tip was also observed in a substantial sample of females. These observations corroborated with the findings of other studies where the authors reported increased length and width of the tongue in males compared to females.

All the participants included in the study were free of any pathology affecting tongue, habits and systemic illness. Features such as indentations in the lateral borders and geographic tongue were not observed. This study would serve as a pilot survey for the use of tongue prints in biometrics and forensic investigations. Future attempts with a larger sample size and inclusion of stringent criteria are warranted. Further research evaluating the effects of other pathological conditions on tongue prints is recommended.

CONCLUSION

This study represents a preliminary analysis of tongue features and its variations with respect to gender. A simple methodology to obtain lingual impression has also been tested and recommended. This simple procedure of obtaining lingual impressions can be adopted by dentists as a chairside technique. Large-scale studies should be conducted to determine the common presentation of tongue features among males and females. Database creation is mandatory to explore the use of tongue prints in forensic dentistry. Dentists can play an important role by collecting images of the tongue and prepare a cast routinely for the patients along with their other dental records. This would serve as a database and a guide for identification purposes. To conclude, tongue print being a unique record and one that cannot be forged is a better biometric authentication tool than others, and since it is personalized and constant, it can be used for forensic identification purposes too.

Conflicts of interest

There are no conflicts of interest.

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