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. 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. 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 significantly from one individual to another. The shape and texture of the tongue can be used as a unique identifier for authentication purposes.
Tongue prints vary a lot. 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.

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. The tongue provides both static and dynamic features for authentication. 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. Recently, tongue recognition systems based on 2D dual-tree complex wavelet transform have been proposed by Bade et al. Tongue scanners are under research and being tested.

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. 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.

**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. 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
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. 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. Research on tongue prints is at a preliminary stage. A study by Diwakar and Maharshi reported tongue as a reliable member of biometrics family. Application of tongue biometrics system in public-use system such as banking system has been proved by Naaz et al. in 2011. 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. Implications of tongue prints and 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.\textsuperscript{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.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Liu Z, Yan JQ, Zhang D, Tang QL. A Tongue-Print Image Database for Recognition. Proceedings of the Sixth International Conference on Machine Learning and Cybernetics, Hong Kong; August, 2007. p. 19-22.
2. Diwakar M, Maharshi M. An extraction and recognition of tongue-print images for biometrics authentication system. Int J Comput Appl 2013,61:36-42.
3. Available from: http://www.dentistryiq.com/articles/2014/01/new-oral-features-can-be-considered-unique-as-a-fingerprint.html. [Last accessed on 2015 Jun 24].
4. Gaganpreet K and Dheerendra S. : A Novel Biometric System based on Hybrid Fusion Speech, Signature and Tongue. International Journal of Computer Applications 2015; 119:30-39.
5. Musa OA, Elsheikh TE, Hassona ME. Tongues: Could they also be another fingerprint? Indian J Forensic Med Toxicol 2014;8:1171.
6. Suryadevara S, Naaz R, Kapoor S, Sharma A. Visual cryptography improvises the security of tongue as a biometric in banking system. In Computer and Communication Technology (ICCCCT), 2011 2nd International Conference; 2011. p. 412-5.
7. Bade A, Chavan K, Admane P, Komatwar R. Tongue recognition system for authentication. Int J Res Appl Sci Eng Technol 2015;3:76-80.
8. Available from: https://www.prezi.com/0o1lr5lssutc/tongue-scanner. [Last accessed on 2013 Oct 21].
9. Bhattacharya D, Ranjan R, Alishrov AF, Choi M. Biometric authentication: A review. Int J U E Serv Sci Technol 2009;2:13-27.
10. Stefanescu CL, Popa MF, Candia LS. Preliminary study on the tongue-based forensic identification. Rom J Leg Med 2014;22:263-6.