Review Article

Tongue prints: A novel biometric and potential forensic tool

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Abstract

Tongue is a vital internal organ well encased within the oral cavity and protected from the environment. It has unique features which differ from individual to individual and even between identical twins. The color, shape, and surface features are characteristic of every individual, and this serves as a tool for identification. Many modes of biometric systems have come into existence such as fingerprint, iris scan, skin color, signature verification, voice recognition, and face recognition. The search for a new personal identification method secure has led to the use of the lingual impression or the tongue print as a method of biometric authentication. Tongue characteristics exhibit sexual dimorphism thus aiding in the identification of the person. Emerging as a novel biometric tool, tongue prints also hold the promise of a potential forensic tool. This review highlights the uniqueness of tongue prints and its superiority over other biometric identification systems. The various methods of tongue print collection and the classification of tongue features are also elucidated.

Key words: Biometric authentication, forensic dentistry, lingual impression, tongue, tongue print

Introduction

Tongue is a vital organ which performs multiple actions such as articulation of speech, perception of taste, and formation of food bolus. It is well protected from the external environment and enclosed in the oral cavity with palate on the superior aspect, floor of the mouth on the inferior aspect, mandibular teeth on the lateral aspects, pharyngeal region posteriorly, and the lips anteriorly.[1] Biometric authentication is a method of personal identification and has gained popularity in the recent years. The necessity for security in cases of bank details, transactions, etc., has propelled the research in the field of biometrics. In biometric authentication, the input sample is compared against a sample template to identify the person. Fingerprint, palm print, iris scan, signature scan, etc., are the different biometric methods in use.[2] Recently, there has been an increased interest in tongue prints as a biometric tool. This review highlights the uniqueness of tongue prints and its advantages over other biometric methods. Different methods of tongue print collection, classification, and its potential application in the field of forensic dentistry are also discussed.

Uniqueness of Tongue

Tongue is a vital organ, and its vitality is described in Traditional Chinese Medicine (TCM) as "Tongue of life"

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where the tongue has a vital color. In contrast, the "Tongue of death" in TCM is termed so due to its dark and withered appearance. Its uniqueness is further showcased by the fact that since it is an internal organ, it is a proof of life that is whether the person is alive or dead. Only when a person is alive can they protrude the tongue for examination purposes. Many a times, death occurs when the tongue falls back to obstruct the airway, especially in cases of sleep apnea.[3] Second, the analysis of shape, texture, and color reveals visible differences between one individual and another thereby making it a useful tool in personal identification. It conveys a lot of information regarding the health status of an individual. Hence, it has been commonly studied and evaluated in TCM.[4]

The tongue like any other organ has its share of skeletal muscles, blood vessels, and nerve supply. In addition, it is bestowed with papillae and taste buds. In TCM, it has been observed and stated that the general texture of the tongue varies between individuals and since it is affected by diseases, it can be a useful tool in identifying medical conditions. Simple visual comparison can indicate clear differences.[5]

Tongue Print versus Other Biometric Systems

The different biometric systems that are employed for security purposes are fingerprint, retinal scan, skin color, voice check, palm print, face scan, signature check, etc. Each of these systems has their own advantages and disadvantages. The disadvantages for each system make it vulnerable for security breach and also a hassle in identification purposes. Fingerprints can be eroded, changed due to work, altered by surgery, and subjected to injuries and burns, so they are not stable. When voice is considered, it is affected by sicknesses such as cold and cough. In case of extreme emotional states, there are chances of misspoken words. Retinal scan is highly sensitive. It is dependent on the user and can be affected by bright light and diseases such as cataract and astigmatism. Skin color is also one type of biometric system, but it presents with stability problem as considerable differences are seen with age, burns, diseases, and use of skin creams or medications.[6]

Numerous advantages exist in using tongue print over other biometric systems such as fingerprint, voice check, and retinal scan. The 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.[7] In recent years, tongue print is gaining momentum as an important tool in biometric authentication.

Tongue Print Collection and Identification

Tongue prints can be obtained in different ways. A simple visual inspection of the tongue reveals many features such as the color of the tongue, mobility, surface textural variations, and any other special characteristics if present. Digital photographs of the tongue can be captured and matched with a database for verification. They can also be used to identify the shape of the tongue. The shape of the tongue is obtained by joining three reference points. A study carried out in Hong Kong Polytechnic University in 2007, was designed to develop tongue image database, which included both tongue geometric shape and surface textures of individuals, and this database was assumed to be a valuable resource for assessment, comparison, and evaluation.[8] Three-dimensional analysis of the tongue is a viable option for assessment. Analysis of the tongue can be performed by taking an alginate impression followed by cast preparation.[9] This helps in capturing the unique features and reproducing them onto a cast which can be used for study purposes. Digital software has been formulated which autocorrects for the color and hue along with the positional alterations and camera conditions and then analyses the tongue for its color and texture to match with its database to bring about positive identification. Many studies have been researched into preparing a proper algorithm for tongue image analysis.[10] Other methods tried are capturing the video of a tongue and extracting images from the same as the tongue is a nonrigid organ. Alternate method includes sublingual vein analysis, which is one of the common methods employed in tongue diagnosis.[11] An ultrasound technique has been employed using an ultrasound transducer placed in the sublingual area to analyze the tongue function.[12] Histological examination of the tongue can also be undertaken.

Tongue Prints in Forensic Dentistry

The dorsal surface of the tongue is unique for each person. The characteristic features of the tongue exhibit remarkable difference even between identical twins.[13] Lingual impressions (impression of the dorsal surface along with the lateral borders) have been proved to be useful in forensic dentistry identification when used in conjunction with methods such as cheiloscopy and rugoscopy.[14] Its use in natural and humanmade disasters is yet to be documented although the tongue is one of the main components for diagnosis in TCM.

Classification

The different aspects of the tongue that are considered for assessment are vitality, color, shape, moisture, and movement in case of living cases. The surface coatings of

the tongue are also further classified based on the color which is normally clear-white and of thin uniform layer. Alterations in these characteristics depict illness and can be used for diagnostic purposes.

The characteristic features observed on the dorsal surface of the tongue have been classified by various authors in different studies [Table 1].[9]

Tongue fissure refers to the presence of grooves or furrows present on the dorsal surface of the tongue. They can occur as a single groove or multiple grooves. They can either be shallow or deep. Smooth tongue refers to a tongue devoid of any fissures or cracks. The shape of the tongue is analyzed by taking reference points on the lingual tip and the V-shaped lingual sulcus. Other variations which have been observed on the tongue is the presence of a fibrous band in the tip of the tongue, mild or a partial cleft in the tip of the tongue appearing as bifid tongue, etc., can also be seen. Another classification was put forth by Stefanescu *et al*. in 2014 [Table 2].[9]

Sexual Dimorphism in Tongue Characteristics

When considering sexual dimorphism, it has been observed that scrotal tongue and geographic tongue were characteristic of female patients. Patients with sharp tip at the lingual apex were females and males had septate tips according to a study. The length and width of the tongue differed between males and females, with males having an increased length and width compared to females. In histological examination, it has been observed that there is a significant difference in the orientation of the muscle fibers of the tongue among men and women. This difference is characteristic in the middle region of the tongue.[9]

Table 1: Classification of features on dorsal surface of tongue

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

Table 2: Classification of tongue features by Stefanescu *et al.*

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

Conclusion

The tongue is a unique organ exhibiting many static and dynamic characteristics which differ considerably between individuals. Use of tongue prints as a biometric authentication tool has been under research, and studies have found it to be beneficial and comparable to other biometric tools. Research on the potential of tongue prints as a forensic tool is warranted.

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Conflicts of interest
There are no conflicts of interest.

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