REVIEW ARTICLE

# Role of Tongue Prints in Forensic Odontology and Biometrics: A Systematic Review

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## ABSTRACT

***Objective:*** **Tongue prints can be used for human authentication. Similar to finger prints, the features of the tongue are unique and differ from individual to individual. The aim of this review was to verify the prevalence of Tongue traits and how far Tongue traits are useful in forensic identification.**

***Material and Methods:*** **Systematic search was done at databases Scopus, PubMed, EBSCO, Cochrane Library, Embase and Web of Science between January 2005 and December 2020 for identification of articles addressing the prevalence of tongue traits and its usefulness in forensic identification. The systematic review was carried out which adopted the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-analysis.**

***Results:*** **The search identified 170 references. 30 articles were selected and evaluated. All of the studies included in the systematic review showed a low risk of bias.**

***Conclusion:*** **Tongue is unique with its characteristic traits which are distinctive for personal identification. Tongue printing is becoming a novel biometric tool and also a powerful forensic tool.**

## KEY WORDS

**biometrics, forensic odontology, tongue prints; forensic tool**

## INTRODUCTION

Forensic Odontology deals with the examination of hard and soft tissue injuries, evaluation in human abuse, identification of an individual in criminal investigation and mass disasters, bite mark analysis and produces them as expert witness in the court of law[1)].

Biometrics is the measurement and statistical analysis of a person's physical and behavioral characters, which are used for his authentication. Depending on these characters different body parts like iris, finger prints, facial geometry, voice, signature etc or fundamental nuclear structure, the DNA are used in biometrics. Among all these methods DNA gives more accurate results as it shows very less changes throughout the life[2,3)]. All other methods have their own pros and cons to at least some extent.

One of the recent trends used in Forensic Science is Tongue prints[1)]. In Traditional Chinese Medicine, the vitality of tongue is described as "Tongue of Life" due to its vital color while the dark and withered appearance of tongue is described as "Tongue of death"[4)]. In Traditional Chinese Medicine, tongue examination was done for identification of various diseases. According to Amit Bade *et al*, use of tongue prints for identification of a person was first proposed by Zhi Liu in 2007[5)]. This paper presents the nutshell of studies accomplished on tongue prints in past 15 years.

Received on May 19, 2022 and accepted on June 3, 2022

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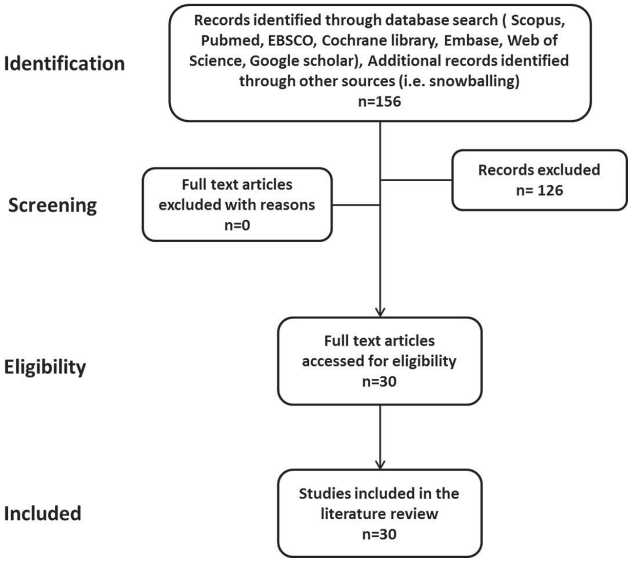


**Figure 1: Consort flow chart of included studies**

## MATERIAL & METHOD

In accordance with the Cochrane Collaboration, the present systematic review was carried out which adopted the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-analysis[6]. Study questions were generated using patient attributes, type of intervention, control, and outcome (PICO). The following were the focus questions analyzed in this analysis: "

1. "What is the prevalence of Tongue traits?"
2. "How far Tongue traits are useful in forensic identification?"

Databases such as Scopus, Pubmed, EBSCO, Cochrane Library, Embase and Web of Science were systematically analyzed for the selection of articles between January 2005 and December 2020.

### Collection of Data:

The key evidence in the papers was compiled by a reviewer (SMM) and the analysis of the studies was provided by two reviewers (KKG and BNS). A third reviewer (MS) was contacted in the event of a doubt. The following data were collected from the selected studies: year of publication, country, authors, study design, prevalence of tongue texture and shape, longitudinal grooves in tongue, pattern of lingual tip in tongue, types of tongue borders and variation related to tongue size and tongue color and period of evaluation.

### Bias Analysis:

Analysis of bias was done independently in the selected papers for quality using the methodological index for non-randomized studies (MINORS)[7].

## RESULTS

The flowchart (Fig. 1) presents the process of number of included articles for literature review after electronic database search.

## DISCUSSION

Tongue prints are one of the emerging trends in forensic odontology and biometrics. With advancement in the technology and lifestyle, human beings have not only benefited, but are also exposed to a variety of untoward mishaps. One such situation is mass disasters leading the death of human beings at a large scale beyond recognition. Personal identification becomes challenging on such occasions and over the past few decades considerable research is being carried out and new methods of personal identification have been emerging from time to time, each claiming to be better in its reliability. For decades personal identification has been based on blood and saliva samples, bite marks, hard tissues such as teeth, bone etc. Hard tissues such as bones and teeth were preferred over the other methods as these tissues are more resistant to extreme conditions including high temperatures. In this context, new area of research in the form of tongue and its traits have been identified as a promising forensic tool in personal identification.

Unique characters of tongue that are used in tongue recognition[2] are tongue color, grooves on the tongue, tongue tip, surface texture of the tongue, length of the tongue, width of the tongue, tongue shape and histological composition. Tongue prints recording[4] were done using visual inspection, digital photographs, cast preparation from alginate impression of tongue prints, capturing video of the tongue, sublingual vein analysis, ultrasound technique, histological examination, modified hand held color scanner[8].

Advantages of tongue biometrics[9] are Universality - Tongue prints show specific traits in an individual, Uniqueness - within a group of population, tongue prints show adequate difference among the individuals, Permanence- There is no significant change in tongue prints over a period of time except in case of some physical trauma or due to some disease, Measurability - Tongue prints can be easily obtained and digitized, Performance - Tongue prints show recognition accuracy and Circumvention - Tongue prints show least circumvention as they can't be easily forged.

### Limitations of tongue biometrics:

Tongue is a movable organ and hence, to maintain the same position whenever tongue print is captured is the basic limitation. According to Saini et al, during biometric procedures different positioning of sensors, noise, imperfect imaging conditions may cause problem to perfectly match two samples of same biometric characters[9]. All these limitations are also applicable to tongue biometrics. So, biometrics predominantly depends on matching score. Higher the matching score between the input and the database, more are the chances that two samples coincide.

### Tongue biometrics:

Tongue biometrics was first proposed by Zhi Liu and Jing-Qi Yan *et al* in 2007. For 134 subjects 3D tongue image database was created and it was observed that contour of tongue is constant over a period of time and can be used for verification (human authentication)[5]. In tongue biometrics, numerous techniques like 2D Dual Tree Complex Wavelet Transform[10], WLD (Weber Law Descriptors)[11] and combination of techniques like Histogram with SIFT (Scale invariant feature transform)[12], Local binary pattern with Linear Support Vector Machine technique,[13] were studied to increase the precision of authentication.

Gaganpreet *et al* used hybrid method, fusion of three biometrics that is tongue prints, speech and signature. He used MFCC technique (Mel Frequency Cepstral Coefficient), DCT technique (Discrete Cosine Transformation) and SIFT techniques respectively for the extraction of features and observed 88.75% accuracy in non-noisy samples and 80% accuracy in noisy samples[3]. Similarly, Olajide AY et al studied a bimodal biometric system, Principal Component Analysis (PCA) for the extraction of feature from tongue and ear images and Self Organizing Feature Map (SOFM) for training and testing of the system. By this method they observed an accuracy of 99.78%[14]. Salim Lahmiri compared the tongue prints texture analysis by three different methods i.e., wavelet transform, Gabor filter, and spectral techniques that showed wavelet analysis with the best accuracy (92%), least accuracy with spectral analysis (75%) and Gabor filter recognition was in between with 83% accuracy rate[15].

### Tongue prints as a forensic tool:

Tongue prints are mainly studied to know the predominant characters of tongue that are common, to identify sexual dimorphism and ethnic differences. The predominant features observed in both the genders were the smooth borders[16], rough texture[17], and U-shape tongue[15,16,18-20]. In contrast, Abraham Johnson *et al* observed rectangular or square as predominant shape in both the genders[18].

Rachel M Stange *et al*. studied the lingual morphology in two different families by photographs[21]. It was observed that U-shaped tongue and vertical fissures were predominant compared to the other types. All the family members in family A, showed U-shaped tongue and family

**Table 1: Tongue print characteristics and results of selected articles.**

| Author & Year | Texture | Shape | Longitudinal grooves | Lingual Tip | Size | Color | Border |
|---|---|---|---|---|---|---|---|
| Stefanescu Corina Laura *et al*.[25] | • Physiological Tongue<br>• Scrotal Tongue<br>• Geographic Tongue | • Ovoid<br>• Ellipsoid<br>• Rectangular<br>• Pentagonal<br>• Trapezoidal to Asymmetrical. | • Depending on visibility<br>▪ Perceptible<br>▪ Imperceptible<br>• Shape: Rectilinear/ Twisty<br>• Depth: Superficial/ Deep. | • Sharp<br>• Septate | | | |
| Zhang B and Zhang H[30] | • Health: Circular, Square<br>• Disease: Rectangular, Acute, Obtuse | | | | | | |
| Abraham *et al*.[18] | • Normal<br>• Cleft /Bifid<br>• Plaqued<br>• Geographic. | • Square/ Rectangular.<br>• Triangular<br>• Circular | | | | | |
| Pradhakshana Vijay *et al*.[16] | • Smooth<br>• Rough<br>• Ulcerated<br>• Hairy<br>• Edematous<br>• Nodular | • Long and Broad<br>• Short and Broad<br>• Short and Narrow | • Fissured<br>▪ V- Shaped/ Coated<br>• Branched<br>▪ Horizontal/ Vertical/ Patternless<br>• Cleft<br>• Geographic pattern<br>• Hairy Tongue. | • Pointed (V—Shaped)<br>• Blunt (U—Shaped) | • Small<br>• Large | • Pale<br>▪ Pink<br>▪ Reddish<br>▪ Whitish<br>• Brown<br>• Pigmented | ▪ Smooth<br>▪ Scalloped<br>▪ Ulcerated<br>▪ Nodular. |
| Sreepradha *et al*.[26] | • U-Shaped<br>• Bifid<br>• V-Shaped | • Absence of fissures<br>• Single fissure<br>• Multiple fissures | | | | | • Smooth<br>• Partially scalloped<br>• Scalloped. |
| Rachel M Stange *et al*.[21] | • U — Shape<br>• V — Shape | | • Vertical<br>▪ Singular<br>▪ Multiple<br>▪ Straight<br>▪ Wavy<br>▪ Deep<br>▪ Shallow.<br>• Horizontal<br>▪ Singular<br>▪ Multiple<br>▪ Straight/ Wavy<br>▪ Deep/Shallow | | | | |

B, showed V-shaped tongue. However, it was observed that there was variation in the fissure pattern. In family B, none showed horizontal fissures[21].

## Morphological characters of tongue that exhibit sexual dimorphism:

The studies regarding the morphological traits of tongue showed varied findings. Venkatesh SB et al observed that U- and V-shaped tongue was significantly higher in females compared to males[22]. In contrary, Abarnalingam *et al*.[23] and Garg *et al*.[24] observed U-shaped tongue was common in males and V-shape in females. Sharp tip was predominant in females and septate/blunt tip in males[16,18,25]. Geographic and scrotal tongue were characteristic of females[18,25], in contrast Pradhakshana *et al* observed geographic tongue more in males compared to females[16]. In males, predominantly multiple vertical fissures and central fissure in females were noted[19,26]. In another study revealed that the fissures were predominantly absent in females and in males, central fissure was common[20]. Jeddy N *et al* have found that shallow fissures were predominant in males, while in females the fissures were deep[1]. When the tongue size was observed, males have wider and longer tongue compared to females[20].

Characters of tongue that exhibit ethnic difference: Beghini M *et al* studied the morphometric analysis of tongue and collagen content in two ethnic groups (African ancestry and European ancestry) and found that the individuals with African ancestry had significantly longer tongue, while the individuals with European origin had higher collagen content in the tongue[27]. Abarnalingam *et al*.[23] studied lip prints, tongue prints and palatal rugae in 90 subjects of Karnataka, Tamilnadu and Kerala, 30 of each ethnic group and it was found that there was no significant correlation among lip prints, tongue prints and palatal rugae among three ethnic groups. Swapna Bettanapalya Venkatesh *et al*.[22]

studied the morphological traits of tongue in 250 participants of three ethnic groups that is Indians, Malaysians and Chinese which showed that deep fissures were significantly higher in Indians and shallow fissures in Malaya race compared to other groups.

Applications of tongue biometrics[10,28,29] are useful in Identification of culprits, Account access, ATMs, Visual cryptography[29], Online banking, PC/Network access, Employee access, Access to personal information, Patient identification, Air travel, Border crossing and Passport. Similar to Tongue biometrics, tongue base security improvisation can be achieved by Visual Cryptography method[29].

## CONCLUSION

Tongue prints being unique, can't be forged. It is a better tool for identification of a person. They are one of the emerging concepts in forensic odontology and biometrics. Not much of research on tongue prints as a forensic tool was done and hence, more studies in this area should be encouraged which may shed more light. This aids in creating database of tongue for identification purpose that could help in defining criteria to formulate a specific classification to include all morphological characteristic features. Extensive research should be conducted to explore the use of tongue prints.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

## ETHICAL CLEARANCE

Not applicable

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