JOURNAL LA MEDIHEALTICO

VOL. 06, ISSUE 02 (217-229), 2025
DOI: 10.37899/journallamedihealtico.v6i2.1396

Role of Tongue Print Examination in Forensic Odontology Identification

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Article Info

Article history:
Received 24 June 2024
Received in revised form 4 November 2024
Accepted 21 February 2025

Keywords:
Tongue Print
forensic Odontology
Identification

Abstract

The tongue is a part of the oral cavity that is easy to examine. The tongue is very well protected from the external environment so that it can be adequately examined even though some other body organs have been damaged. The tongue has identical characteristics in each individual, so it can be used to identify a person. Several studies have been conducted, it has been found that there is a tendency for particular features of the shape, size, and structure of the tongue to be different in men and women. Therefore, it can be utilized by forensic odontologists as a support in an individual identification process.

Introduction

The dorsal surface of the tongue is unique in each individual. This distinctive tongue feature shows differences in each individual, even among identical twins. The shape and texture of the tongue can be analyzed at any given moment, this organ is very helpful because it consists of information that shows differences from one individual to another (Malik et al., 2022; Vijay et al., 2019). Tongue prints (prints of the dorsal surface along with lateral boundaries) are helpful in forensic dentistry identification when used with other methods, such as fingerprints, palmprints, iris images cheiloscopy and rugoscopy, to identify suspects during forensic investigations (Zhang et al., 2007; Khan et al., 2023; Rusmaputeri & Auerkari, 2025; Sust, 2021).

While tongue prints offer promising applications in forensic odontology, it is important to compare them with established biometric methods such as fingerprints and dental records. Fingerprints, although widely used, can suffer from alterations due to aging, scarring, or environmental damage. In contrast, tongue prints—characterized by robust three-dimensional features—may exhibit greater resilience and reliability under specific conditions (Khan et al., 2023; Arora & Kaur, 2019; Li et al, 2025; Li et al.,2023). The tongue is an internal organ easily removed from the mouth for examination. However, the tongue is a well-protected organ from the external environment. It is enclosed in the oral cavity by the floor of the mouth in the inferior aspect, the palatal in the superior aspect, the pharyngeal region in the posterior, the lips in the anterior, and the mandibular teeth in the lateral aspect. Based on this, the tongue is an easily used organ to identify individuals and other evidence and identification systems (Malik et al., 2022; Arora & Kaur, 2019).

Visual inspection and digital tongue photography have been tried and adopted methods so far. This examination displays information about geometric shapes and physiological textures potentially valuable for human identification (Rogers et al., 2022; Fu et al., 2024; Bowers et al., 2023). This information shows the dorsal morphology of the tongue, its shape, and its tip.

ISSN 2721-1215 (Print), ISSN 2721-1231 (Online)

Gender dimorphism can be studied with data on tongue characteristics that have been examined (Malik et al., 2022; Obid et al., 2023).

Dental records are also critical in forensic identification, particularly due to their permanence and ability to reflect individual characteristics like dental treatments and anomalies (Sehrawat & Ahlawat, 2022; Saxena & Deheriya, 2023; Dahal et al., 2023; Giannakopoulos et al., 2024). However, tongue prints could serve as a supplementary tool, providing an additional layer of verification when dental records alone are insufficient. This combination could be particularly useful in mass disaster scenarios, where comprehensive identification methods are crucial (Arora & Kaur, 2019; Ba et al., 2021; Abid et al., 2021; Zheng et al., 2021).

Broader Context of Forensic Identification Tools

Expert identification systems have dealt with the complex problem of proving absolute certainty during cases when identity evidence is partly destroyed or completely missing. Traditionally forensics science depends on fingerprints along with DNA profiling and dental records and facial recognition as its basic pillars which have stood the test of time because of accumulated empirical evidence and technological progress along with judicial willingness to accept them (Harrel, 2021; Pizzolato, 2023; Tawiah et al., 2024). Various constraints exist which shape the actual operations of these methods even though they appear dependable at first glance. The widespread use of fingerprints cannot prevent their destruction through various agents which includes physical abrasion, thermal damage, autolysis or intentional medical intervention (Nayak et al., 2022).

Although DNA testing exhibits exceptional precision it cannot withstand every challenge because its execution depends on specific laboratory equipment and lengthy processing time and the use of pure biological materials which field investigations might lack (Viner & Massey, 2020). The identification process through dental records needs complete antemortem dental documentation in order to function effectively in postmortem identification procedures. Many critical cases involving underserved or displaced populations become without identification possibilities because these populations lack necessary antemortem documentation (Pretty, 2007; Kase & Batdorff, 2023; Schmid & Raju, 2021).

The fundamental problem in forensic identity determination stems from an epistemological flaw where scientists attempt to reduce human identity to static biomarkers. The process of identifying humans proves probabilistic because natural conditions combined with environmental factors and contextual aspects influence its outcomes. The discovery of tongue prints as alternative identification markers forces the forensic community to reconsider their systems for both understanding and functioning with identity. The tongue stands unique due to its advantageous characteristics when compared to standard organs and visible features. Postmortem conditions do not easily harm the tongue anatomy because it exists inside the mouth yet remains easily accessible. The tongue provides reliable biometric data as it stands up against fire damage and water exposure and decomposition stages thus making it valuable for mass disaster and war zone and concealed or violent crime scene investigations (Sangala et al., 2022; Erskine & Armstrong, 2021).

The dorsal tongue surface displays personalized patterns of papillae textures as well as shape variations which provide adequate details for forensic identification (Malik et al., 2022). Studies show that these tongue patterns demonstrate both temporal reliability alongside unique variations between participants which include monozygotic twins and male-female differences (Khan et al., 2023). Scientific understanding of tongue print patterns continues its developmental path toward practice but the theory proposes additions to current identification systems particularly during method limitations and inadequacies. The study of tongue prints allows forensic science to evolve into an interdisciplinary framework which confirms identities by combining various biometric evidence sources.

New methods entering the forensic field need to be developed with proper evaluation of experimental rigor and ethical boundaries alongside valid proof of their use. Most existing studies about tongue prints remain small in scale and limited in their population application and validation. applications of tongue print analysis face the unsafe scenario of incorrect assumptions because of generally drawn conclusions. Results from multi-ethnic extensive studies spanning long periods of time will help prove the unique features and durability and usefulness of tongue prints across different settings. Every biometric system needs assessment through the standards of accessibility control and ethical administration and reproducibility requirements. The domains of data protection and consent use as well as misuse concerns affect tongue print analysis by the same extent they impact other biometric identifiers. Tongue prints demonstrate their scientific ingenuity yet their actual forensic usefulness will become evident when scientists validate these fingerprints and show their practical need while understanding the forensic environment they need to address.

Body

Tongue Print

Examination of tongue prints in the process of visually identifying individuals based on shape, size, color, texture, and other specific features (Hegazy, 1955). The typical structure of the dorsal surface of the tongue is stratified squamous epithelium, with many papillae and taste buds scattered on the tongue's surface. The papillae on the tongue are divided into four types located on certain tongue parts. Filiform papillae have the most number but no taste buds. These papillae are formed by increased keratinization and are involved in the mechanical aspect of providing abrasion.

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

The circumvallate papillae are arranged in an inverted V shape behind the sulcus terminalis towards the base of the tongue. Fungiform papillae are located mainly on the dorsal surface of the tongue and on the sides. The papillae of the foliate are located in the posterior part of the tongue of the lateral border (Godbole et al., 2020).

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

Different specific features of the tongue are found in each individual, and the size of the tongue can be identified through comparison with the size of the oral cavity. Various tongue shapes found in individuals include oval, round, septate, triangle, square, rectangle, ellipse, and hammer. Another distinctive feature of the tongue is a notch at the lateral border and geographic tongue (Radhika et al., 2016; Stefanescu et al., 2014).

Analysis

The most feasible analysis for the examination of the tongue is three-dimensional analysis. The most faithful impression intended for study models is the alginate-moulded impression, which has the advantages of duplicating the most minute details and coming off the model easily. This three-dimensional analysis can be performed by printing the tongue antagonist using alginate and casting it with a cast. This tongue printing is done by applying alginate on the surface of the dorsum tongue from the level of the oral commissures up to the lingual tip, including the edges. Digital imaging can also be done to see the original color and match the tongue's position with a three-dimensional tongue print (Nimbulkar et al., 2020; Bhattacharyya et al., 2023; Mani et al., 2021).

The analysis of tongue prints emphasizes the feasibility and necessity of three-dimensional (3D) analysis for forensic purposes. 3D analysis allows for a comprehensive examination of the tongue's surface, capturing details such as texture and fissures that two-dimensional methods might overlook. This level of detail is crucial for accurate individual identification, especially in cases where subtle morphological differences are significant (Nimbulkar et al., 2020). The use of alginate-moulded impressions is a practical method to capture these fine details. Alginates, commonly employed in dental practices, are favored for their ability to replicate the tongue's intricate features, from the oral commissures to the lingual tip. The impressions maintain the spatial relationships among features, which enhances the accuracy of identification. Following the alginate impression, a detailed cast can be created, preserving the tongue's surface features comprehensively (Nimbulkar et al., 2020; Bhattacharyya et al., 2023).

Additionally, incorporating digital imaging technology enriches the analysis by capturing the tongue's color and position in three-dimensional space. Digital tools facilitate efficient comparison and documentation, creating accessible databases for forensic analysis. These technologies align with contemporary forensic science practices, improving both precision and efficiency (Nimbulkar et al., 2020; Mani et al., 2021). Tongue fissures refer to the presence of indentations or grooves present on the surface of the back of the tongue. They can appear as a single groove or multiple grooves. They can be shallow or deep. A smooth tongue refers to a tongue without crevices or cracks. The shape of the tongue is analyzed by taking reference points at the lingual tip and the lingual sulcus which are V-shaped. Other variations that have been observed on the tongue are the presence of fibrous bands at the tip of the tongue, slight or partial slits at the tip of the tongue that look like bifid tongues, etc., can also be seen (Radhika et al., 2016).

The transition from theoretical concept development to effective forensic application in tongue print analysis faces numerous experimental and technological problems which require comprehensive assessment. The fundamental challenge arises from the need to establish reliable tongue morphology assessment during real-world operational settings. Tongue prints remain underdeveloped since fingerprint analysis has received over a century of methodological improvement. The methods used to gather tongue prints whether by using alginate impression or digital photography need both precise technology and willing subjects who follow contamination protocols while using calibrated image devices. The forensic data reliability decreases when environmental factors like dehydration or illness or traumatic events affect tongue appearance and texture (Mani et al., 2021).

Three-dimensional imaging systems continue to improve yet they maintain high costs and their wide deployment remains limited to forensic labs especially in mass identification emergency areas of lower and middle income nations. The time-sensitive nature and difficulty in usage along with rapid degradation of alginate impressions become serious issues when implemented in the stressful field conditions of mass disaster zones. The field lacks consensus on how to standardize analysis reference points since tongue morphology does not utilize the established

fingerprint method of comparing established minutiae patterns. Standardization is required for laboratories to achieve consistent results between each other.

Although tongue prints hold scientific value their limitations represent the direction for future research development. Tongue morphology serves effectively as a forensic identifier because proper procedural guidelines maintain its accuracy level. Tongue print analysis progress requires both technology development efforts and methodological flexibility that involves testing assumptions thoroughly and controlling variability while improving fundamental forensic science framework structures.

Sex Determination

Tongue prints can be used as a determinant of sex estimation. Several studies have shown significant differences in size, texture, and shape between male and female tongues. The size of the male tongue tends to be more comprehensive than the female's. Similarly, with the size of the tongue length, males have a more extended tongue than females (Jayan et al., 2019; Singh et al., 2020). The texture of the geographic tongue is more common in females than males. Geographic tongue texture and plaque are also found in vulnerable populations aged 40-50. As for younger ages, the texture of the tongue tends to be expected (Johnson et al., 2018).

Other studies found that tongues with a V shape tend to be found in females. At the same time, males tend to have a U-shaped tongue. The condition of the fissure tongue is also quite significant; in males, a type of multiple fissure tends to be found, while in females, single fissure. Males also tend to find a superficial fissure tongue compared to females (Sreepradha et al., 2019; Jeddy et al., 2017; Panchbhai & Parida, 2021). As for the condition of the border of the tongue, males and females tend to have similarities, where, on average, they have a smooth tongue border condition (Garg et al., 2020). In addition to the U and V shapes, the hammer-shaped tongue tends to be found more in male patients, while it is more round/oval-shaped in women (Surendra et al., 2020).

Identification can be made of them in mass disasters that cause human death with conditions that cannot be recognized. Mass disaster events cause casualties on a large scale. For some time, samples of blood, saliva, hard tissues (such as teeth and bones), and bite marks have been commonly used to identify individuals (Garg et al., 2019). Based on studies that have been done, tongue prints are advantageous to help the identification process of forensic odontology. In individuals who are already difficult to identify, tongue prints can support sex determination. This is based on the shape and texture of the tongue that cannot be engineered and is identical to each individual (Garg et al., 2020; Sangala et al., 2022).

Legal and Ethical Dimensions of Tongue Print Biometrics

The implementation of intimate biometric identification technologies in forensic science requires immediate and continuous legal and ethical assessment. Tongue prints represent the latest type of novel biologically internal evidence. At first glance the tongue shows potential as a secure biometric marker which causes minimal invasion to the individual. The fundamental validity around this belief should be urgently examined. The legal system remains unfamiliar with tongue morphology since fingerprints have a legacy position in the forensic community. This body trait exists inside the individual as a deeply personal and internal component since it crosses outside physiological boundaries to reach personal spheres. Conserving tongue prints requires access to the oral cavity because this body area maintains strong personal and medical and cultural sensitivities. Using an organ for forensic identification purposes as a standard creates numerous ethical concerns regarding personal freedoms and privacy along with personal rights.

Tongue print capture research by Bhattacharyya et al. (2023) and Khan et al. (2023) focuses on technical possibilities but fails to analyze durable social and legal considerations of

centralized biometric database construction. What should be the duration for maintaining tongue print data records? Who governs access? Do authorities have the power to retrieve tongue print data under formal legal demands through multiple jurisdictions? The questions about legitimacy of a biometric system constitute its core foundational elements. Biometric data serves as a justice tool until the point where incorrect interpretation or wrongful utilization transforms it into a harmful instrument. For instance during state surveillance and wrongful conviction cases. New biometric technologies introduce similar risks to racial discrimination in policing as facial recognition and fingerprint data showed in the past (Gates, 2011) because they lack public oversight and legal safeguards.

The acceptance of tongue print evidence as courtroom evidence has not been definitively established at present. Recent courts hesitate to recognize tongue print evidence because it lacks the extensive judicial foundation which supports DNA and fingerprint analysis. The Daubert or Frye tests provide judicial standards to evaluate fresh scientific evidence by examining how broadly the methodology receives acceptance and whether it is testable and subject to peer review and error-rate calculation. The absence of extensive validation studies about tongue print evidence diminishes its suitable use in court proceedings. The legal restraint against untested technology applications represents more than procedural difficulties since it reflects wider public wariness about deploying unknown systems in criminal proceedings according to Mnookin (2008).

The use of tongue prints presents multiple implications regarding modern concepts of digital personhood together with bio-ownership issues. The question arises about who maintains possession of digital tongue print information stored at forensic laboratories. After data storage occurs can an individual withdraw their consent privileges? Tongue morphology data will potentially enable future connections to medical diagnoses or genetic data and lifestyle characteristics. Biometric technology evolution generates confusion in the distinction between forensic systems and health monitoring functions thereby creating cross-use problems (Zhou et al., 2021). Tongue biometrics have an uncertain future based not just on technology improvement but also on ethical and legal frameworks that will guide their development. The process should advance by maintaining openness while encouraging community exchanges and taking protective measures in addition to developing new technologies.

Forensic Application Scenarios

The genuine assessment of any forensic identification method occurs when it demonstrates functionality in unpredictable and destructive and ambiguous scenarios representing actual forensic settings. The sincerest value of tongue print analysis exists for its function in unforeseen circumstances that include natural disasters and terrorist acts along with combat situations and major transportation disasters. Bodily remains from such circumstances emerge as fragmented pieces with charring or decomposition occurring so extensively that fingerprints together with facial recognition and DNA evidence may become irretrievable or completely vanish. High-temperature or high-impact situations usually spare the dorsal tongue surface since the upper jaw region and mandible, the oral cavity muscles and dental structures all surround and protect it (Sangala et al., 2022; Nimbulkar et al., 2020).

The scientific community continuously refers to this physical structure but literature remains vague on comprehensive interpretation of its forensic significance. The tongue that survives after death serves as both a physical marker and a passive evidence source which can reveal critical information about force dynamics that harmed the body. The tongue benefits from being difficult to modify superficially therefore making it appropriate for covert investigations that require hiding of identity. Traditional forensic odontological procedures link to dental records but this approach faces complications when antemortem dental records prove incomplete or do not exist which commonly affects both underprivileged dental access

populations and migrants and war-affected communities (Garg et al., 2019). The implementation of tongue prints operates as a supplementary or alternative biometric feature for enhancing mulitmode identification systems. Tongue prints should supplement existing systems rather than replace them because this additional evidence enhances identity verification strength which becomes crucial for legal and historical forensic applications (Khan et al., 2023).

The procedure needs to account for particular circumstances of each case. Criminal forensics operators intending to avoid identification through fingerprint destruction have the tongue as a possible biological backup modality. When collecting evidence from detained individuals police could use tongue prints together with alternative procedures that do not require coercion or force. Multiple serious implementation obstacles exist within these applications. Developing swift and dependable tongue-retrieval methods is essential for both postmortem situations and ensuring that both the evidence remains intact as well as respect for bodily etiquette during handling. The current forensic protocols need to establish contingency plans to handle cases when the tongue undergoes partial damage because this type of examination requires advanced pattern reconstruction methods. Moving forward in tongue variation research should focus on operational superiority during demanding circumstances rather than discovering new methods.

Feasibility and Practicality in Low-Resource or Field Conditions

The success of tongue printing stays dependent on real forensic environments rather than science laboratory circumstances characterized by unlimited resources and controlled settings. The identification process conducted in unstable political regions and disaster-hit areas and poverty-stricken regions primarily takes place in impromptu setups which face severe resource shortages and insufficient time and skilled personnel. Tongue morphology collection through alginate-based impression molding and cast replication remains precise yet labor-intensive and requires trained personnel while being sensitive to environmental factors according to literature by Nimbulkar et al. (2020). Such conditions rarely occur during field operations since mass casualty incidents begin haphazardly and without proper mortuary facilities.

Digital imaging, though more portable and potentially scalable, still faces limitations. Intraoral high-resolution photos require subjects to cooperate for identification purposes and lighting must remain stable while the equipment needs to function in variable environmental temperature conditions combined with limited electricity supply and enduring moist conditions which are all common in field forensic investigations. The utilization of tongue prints becomes harder due to the absence of established digital imaging standards. Inadequate tongue protrusion together with imperfect lighting and saliva droplet formation causes the morphological features to appear differently from one person to another thus reducing forensic reliability. The present limitations of tongue print acquisition have received limited attention from researchers yet they signify that the technology remains mostly theoretical for low-resource settings unless field-adaptive solutions are implemented on par with mobile fingerprint scanners and point-of-care DNA kits.

The disparity demonstrates how forensic infrastructure is disproportionately concentrated across different parts of the world. Limited forensic funding makes it troublesome for countries to invest in new biometric identification systems unless they show evidence of being economical to operate and legally appropriate as well as effective in practice. These locations specifically show potential for tongue prints to contribute value because they have inadequate fingerprint or dental record systems. The contradictory situation demonstrates an inherent problem with how identification technology systems are developed since they need to function effectively under demanding situations rather than ideal prototypes. Obaid et al. (2023) propose utilizing deep learning models together with machine learning models for automated image identification purposes which might decrease human expert needs. The absence of adequate

training datasets prevents these systems from becoming operational since they need substantial data sets from various global populations regarding tongue morphology.

The forensic field should deploy innovative practical solutions because the necessary datasets are unavailable at present. Scientists should create inexpensive tongue imaging equipment based on mobile devices and cloud computing systems that establish distributed data acquisition capabilities. Such an approach would boost accessibility along with international collaborative efforts especially in regions with insufficient centralized forensic capabilities. Although tongue prints have demonstrated their promising characteristics they remain inactive in real forensic investigations because of insufficient infrastructure rather than scientific doubts.

Diagnostic Overlap with Medical Fields

Biological indicators include the tongue which stands as a unique identifier because it manifests both external and internal qualities and adaptive patterns although forensic authorities interpret it as a medical artifact. Medical practitioners across times have applied traditional diagnosis techniques to examine the tongue as a reflection of internal well-being. Current medical research validates this observation through identifying systemic health indicators on the tongue surface including anemia symptoms and diabetes markers and vitamin deficiency signs and liver disease warnings as well as immunosuppression precursors (Johnson et al., 2018; Singh et al., 2020). The tongue surface reveals dehydration, inflammation, infection and atrophy symptoms because they represent overall body conditions. The inner health-to-tongue morphological links create new potential together with moral questions that affect forensic examinations.

Tongue morphology provides valuable diagnostic information which would enhance forensic profiling outcomes. Postmortem identification can use tongue morphology characteristics of geographical tongue along with fissured tongues and minimal atrophic changes to provide information about victim age and sexual identification and prior health conditions before death when dental records and DNA profiles are missing. Tongue fissures together with their type appear to show correlations with both human sex traits and regional population-based health statistics according to Jayan et al. (2019). The utility of performing diagnostic tests in forensic investigations remains valuable but it triggers essential debates concerning investigations that exceed forensic consent limits. In the future tongue-based analysis could expand identification processes to develop profiling abilities that make unsanctioned medical or social background assessments without authorization or environment information.

The ethical boundaries of biometric inference become questionable as a result. A forensic report based on exam findings of tongue malnutrition runs the risk of inadvertently describing social economic status. The mistaken interpretation of oral disease indications might result in incorrect conclusions about individual cleanliness along with behavioral patterns. Current studies do not specifically present these possible situations but these potential events exist throughout the diagnostic systems of tongue-based analysis. Accurate or potential indirect assumptions made during examinations would potentially shape decisions in judicial settings together with immigration situations.

Moreover, this diagnostic-forensic overlap poses legal dilemmas. The laws protecting medical information operate strictly but biometric identification follows separate standards within various countries. The position of tongue prints between medical diagnostics and forensic identification creates an ambiguous legal environment when it comes to regulations. Public organizations currently disagree about whether tongue features applied to identification purposes qualify as protected health information. Other protective measures must be taken to prevent improper use of this dual-use potential because it could lead to profiling detainees based on perceived health traits and denying asylum based on inferred substance use or

malnourishment as documented in Zhou et al. (2021). Tongue print analysis in forensic science needs to advance under ethical guidelines instead of technical capabilities before its implementation. The scientific community and government leaders need to establish firm rules which block medical deductions from entering legal or administrative procedures unless directly permitted by statutes. The tongue will fulfill its dual medical usefulness and identification marking functionality while preserving human rights and dignity only through ethical guidelines.

The Need for Standardization and Population-Based Validation

The forensic use of tongue prints depends on developing standardized methodologies and population-based validation because these form the essential base for credibility in forensic identification. Tongue morphological research can confirm uniqueness for identification (Malik et al., 2022; Garg et al., 2020) although evidence ranges from sparse populations to various procedures and regional groups. Most research studies select specific groups when collecting data which normally comprises mostly young adults who predominantly belong to distinctive ethnic or regional demographics. Very serious doubts exist about whether research findings adequately show universal variability in tongue morphology or whether unknown cultural habits and regional patterns bias the outcomes.

Environmental factors together with genetic elements determine tongue morphology as nutritional practices and oral cleaning methods and systemic illnesses and linguistic behaviors shape the development of tongue muscles (Radhika et al., 2016; Singh et al., 2020). Daily food diet texture selection between coarse and soft food types produces minor changes in tongue mechanical degradation and ultimately modifies its surface design. The risk exists that specific oral pathologies including glossitis and geographic tongue could demonstrate temporal or demographic fluctuations among different population groups. The omission of vital variables by researchers leads to classification mistakes regarding population-specific and temporary features which creates substantial forensic errors.

The problem worsens because of missing standardized collection procedures. Current techniques that utilize alginate impressions with digital photography and 3D scanning systems present distinct differences in their equipment needs as well as the focus areas of anatomy they examine and the detailed data recorded and the interpretation rules for classification grouping. The findings from one investigation become unrepeatable in different settings despite examining similar groups of people. The scientific community lacks agreement about defining a successful match between tongue prints in forensic examination. Does the comparison evaluation use geometric measurements only or do fissure patterns texture and color receive importance as well? Scientists must determine the minimum threshold of variation which exists between different patterns of one individual's tongue prints. A satisfactory resolution to these fundamental questions has not been attained by current investigations (Nimbulkar et al., 2020) which impairs the scientific acceptance of tongue prints as viable forensic evidence.

Standardization functions both as an administrative process and it supports the conceptual framework of knowledge generation. Standardization of biometric systems establishes the definitions for recognized evidence and knowledge and details which authority handles their interpretation. Standardization does not exist as an unbiased process because the selection process reveals assumptions between identity definition and normality standards and technological trust frameworks. The implementation of a worldwide tongue print system depends on collaboration between forensic odontologists, bioinformaticians, jurists and anthropologists. The implementation of a global tongue print system requires extensive databases built from ethical collection methods which need to represent the diverse characteristics of individuals including age variations and both health condition and social status groups.

These kinds of infrastructures need full implementation regardless of their challenges. Tongue prints should be integrated into forensic practice only after ensuring they do not become a repeat of previously deployed inadequate technologies before their scientific and ethical readiness. The implementation of tongue print databases requires absolute commitment to research integrity and systematic access combined with a realistic understanding of biometric science boundaries. Tongue prints need to advance from their current novelty status to achieve forensic tool reliability before they can be implemented effectively.

Conclusion

Criminal identification through forensic methods now discovers potential in the tongue as an investigative tool because of its distinctive structure and ability to survive autopsies and provide biometric fingerprint patterns. This review shows that the forensic differential capability exists for the distinctive features of tongue dorsal morphology including shape and surface embossed pattern together with texture dimensions and measurements. Analysis of tongue prints in three dimensions functions as vital supporting evidence when standard identification markers like fingerprints together with dental records or DNA evidence are not available or deteriorated in the investigation area. The individual characteristics of tongue morphology enable its valuable use in mass disaster investigations together with clandestine forensic analysis and low-resource crisis zones which prove challenging for standard investigation approaches. Tongue print analysis raises ethical uncertainties which should not diminish its potential yet. The limited yet promising research on tongue prints faces two main problems caused by its specific geographical scope and inconsistent research methods as well as the need for longer term research designs. The relationship between tongue morphology and age of the subject together with health conditions and oral hygiene upkeep and cultural traditions remains poorly understood by scientists. The limiting factors for tongue print admissibility in forensic investigations stem from incomplete standardized imaging techniques along with missing universal identification systems and restricted population data databases. Field or postmortem use of tongue prints faces challenges because hygiene issues and technical requirements and social reluctance about accessing the oral region impede practicality.

The fact that tongues function both for diagnostic examination and biometric fingerprints leads to ethical considerations which must be seriously addressed. The way tongue morphology presents can expose medical details along with socioeconomic data which creates privacy concerns and acceptable misuse of forensic information. Forensic use of tongue prints requires that identification boundaries must be established clearly from profiling purposes along with strong legal and ethical frameworks which safeguard individual rights. Future research into tongue print analysis needs to expand beyond technical advancements to incorporate inter-disciplinary knowledge as well as environment-sensitive approaches. Proof of tongue print uniqueness across major demographic groups and health states requires extensive research using large representative populations. Treatment of low- and middle-income regions with specific field-ready forensic solutions should be at the heart of technological developments since these areas hold the most critical forensic need points. The development of data governance policies which forecast potential ethical consequences requires equal emphasis as an essential part of maintaining systems.

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