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DIGITAL PERSONAL IDENTIFICATION: TONGUE AS A FORENSIC GRATUITY

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ABSTRACT

Background: The tongue is a unique body part which have various static and dynamic features that vary significantly among individuals. Few studies have been done the use of the tongue prints for the purpose of personal identification.

Aim: This study aimed to examine the tongue prints in a number of Egyptians and determining how much it is unique for each individual.

Method: One hundred participants of normal living persons have participated in this prospective observational cross- sectional study. They were 68 Females, and 32 males, and their ages ranged from 15- 78 years. A visual inspection was done to see the tongue shape, color, coating, and surface features, then a digital imaging and casts were made. The tongue length and width were taken in the live photographs and the casts and compared for the same individual and among participants in the study.

Results: The tongue showed unique measures for every individual, that differ from other individuals. Casts' measures were longer than live photographs. Males' tongues lengths were longer than females' tongues length. The shape and surface features were different among men and women.

Conclusion: The tongue proved to be a useful tool in Forensic practice. It can be used for personal identification, and sex differentiation, according to a database record. The method used in this study is easy and simple to be adapted by dentists on a daily basis. Further research is warranted on this point to provide more information about the tongue in Forensic Dentistry.

KEY WORDS: Human identification- Tongue impression – Unique- Forensic Dentistry- Digital methods.

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INTRODUCTION

The tongue is a vital organ, that is well-encased inside the oral cavity and is protected from the outside environment. It has distinctive features that differ from one individual to another; even between identical twins. The color, shape, size, and surface features are believed to be characteristic for each individual, and this can be a useful tool for personal identification. The tongue provides both static and dynamic features for personal identification [1].

Many biometric systems are useful in personal identification such as the fingerprints, iris scans, skin color, voice recognition, signature verification, and face recognition. The tongue print can also be an easy and secure method for the personal identification [2].

Moreover, the tongue features show differences between males and females, thus the tongue can help in sex identification. The tongue may be the only clue for personal identification in some disasters and conditions with extensive mutilations of the body. This can be done by comparing dental records with the help of other recognition systems [3].

Human identification using the dental, oral, and para-oral structures has progressed fast over the previous few years. However, the knowledge on the use of the tongue for the purpose of human and personal identification, is scarce and there no enough work on the tongue as a human identification tool [4].

The tongue print is not only an innovative biometric tool that can be relied upon as a good forensic identification tool, but also, its methods of examination is simple, easy, available, and clear for every dentist to learn and apply [5].

Research work on the use of tongue prints as a human identification tool is very few. Studies focusing on the morphology or the measurements of the tongue in different races and localities have been in very shortage and have not been applied on a wide scope to facilitate the comparison between races and people of different ethnic groups [5].

Aim of the work

This work aims at detecting tongue prints in a number of Egyptians and determining how much it is unique for each individual.

SUBJECTS & METHODS

This is a prospective observational cross-sectional study that involved 100 participants of normal living persons (68 Females, 32 males), their age ranged from 15- 78 years.

Exclusion criteria

- Tongue diseases, ulcers, thrush, candidiasis, tongue cancer.
- Special habits, like alcoholism and smoking.
- Systemic diseases are all excluded, e.g., diabetes, hypertension, chronic liver cell failure and chronic heart and kidney failure.

Collection of Tongue Prints

A – Simple visual inspection: for the shape, size, movement, color, coating, moistness, and other findings like cracks/fissures, teeth marks, or any other special findings, e.g., thin mucosa, apparat blood vessels **(Figure 1).**

The sheet used for visual inspection of the tongue is attached at the end of this work (Appendix 1).

The following was examined for the tongue (according to **Radhika et al. 2016**) [6]:

1. Size: Proportional to the size of the mouth.
2. Shape: Tongue shape measurement is a complex process. It was done according to **Dawson et al. (2016)** [7] who described the shape of the tongue as the mid-sagittal tongue shape, and said that it may be oval, rounded, septate, triangular, square, and other shapes, e.g., elliptical, hammer, and rectangular.

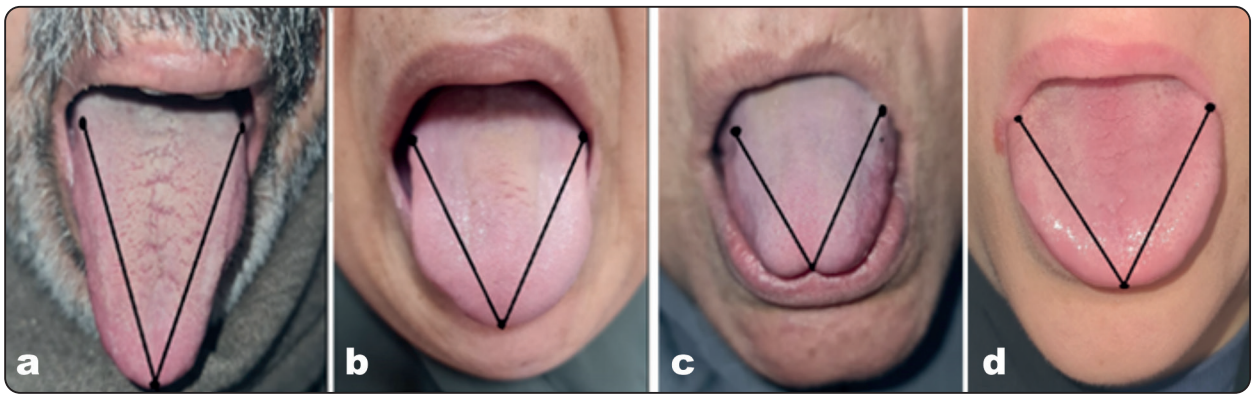

Fig. 1a: Visual inspection of the tongue (a. Triangular-shaped, b. oval-shaped, c. septate tongue, d; rounded).

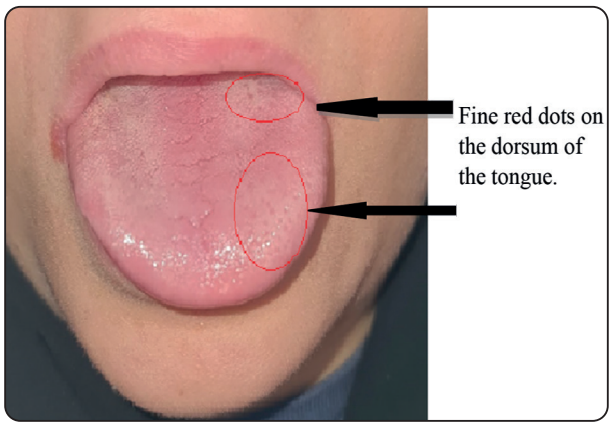

Fig. 1b: Picture (d) magnified to show red dots as specific features on the dorsum of the tongue.

3. Vitality: by inspection; vibrant and vital color especially in the root.
4. Color: normally rosy red, bright and fresh.
5. Moisture: normally moist, wet by a thin film of saliva.
6. Movement of the tongue in living persons: Flexible, nimble, no tremors when protruded outside the mouth.
7. The surface coatings of the tongue: normally it is a clear-white thin uniform layer. Alterations in these characteristics can suspect illness and can be used for diagnostic purposes.
8. Other features like indentations in the lateral borders and geographic tongue.

B- Digital imaging has been done using a digital Canon EOS R5 camera put at a fixed distance from patients' tongue. Then, the photographs were analyzed for the tongue's shape, size, color, coating, and measurements were taken using software systems. There may be also a capturing of an intraoral video of the tongue to re-examine for the tongue's movement, and for extracting images from the videos for the tongue, because it is a non-rigid organ.

The tongue images were then analyzed for the biometric measurements **(Figure 2)**.

The reference points for taking the measurements of the tongue were done according to **Singh et al. (2020)** [8].

The tongue length and width were measured in the live photograph using the appropriate software program. Reference points were made according to **Singh et al. (2020)** [8]. It was taken according to the following points:

a. A point starting from the tip of the tongue; marked as (W11).
b. A point from W11 extending till most lateral point on the posterior third of the tongue, was marked as the point (WY). The posterior part or posterior one-third of the tongue is the root, and it is also known as the pharyngeal or post-sulcal part of the tongue. The root extends from the

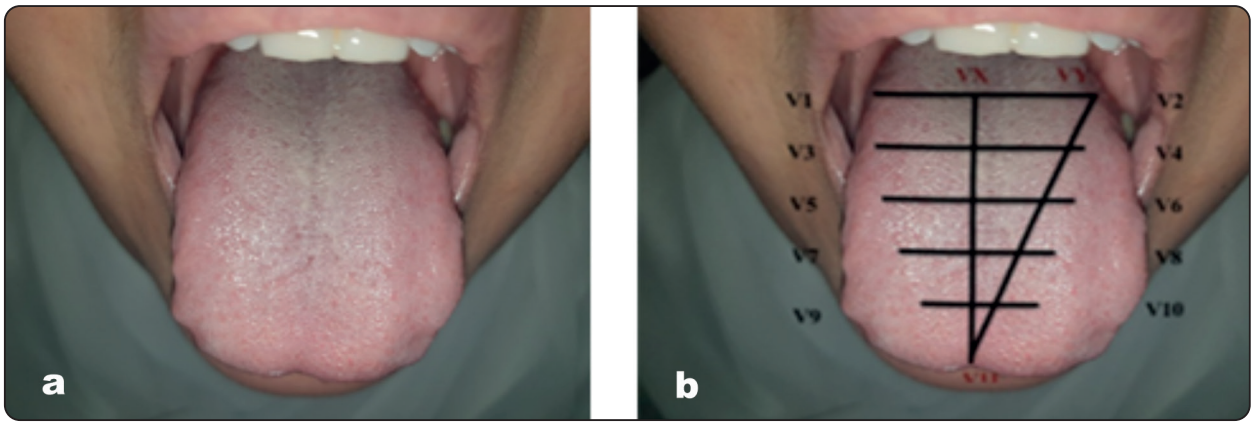

Fig. 2: Digital imaging of the tongue (a) and taking the biometric measurements (b).

terminal sulcus to the epiglottis. It is the broadest and the least mobile part of the tongue, and it houses lymphoid tissues and the lingual tonsil [5].

c. A mid-point at the most posterior line on the tongue was marked as (WX).

These points are illustrated in **Figure 3**.

Then, a line was drawn from WX to W11 dividing the tongue into two halves, and from W11 to WY, making a lateral line with 1 cm- apart points.

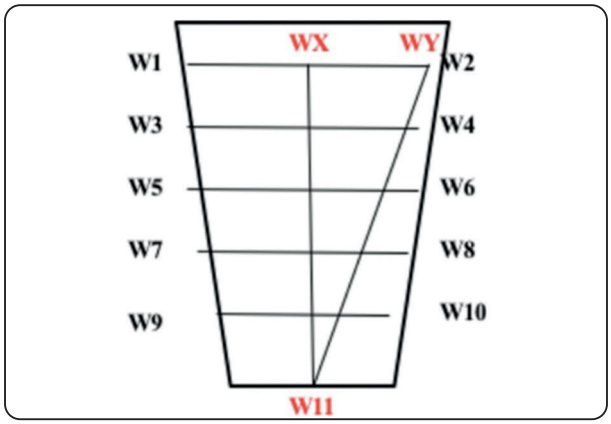

Fig. (3): Reference points to take the tongue measurements (Singh et al. (2020) [8].

C- Taking the alginate impression followed by a cast preparation (Figure 4).

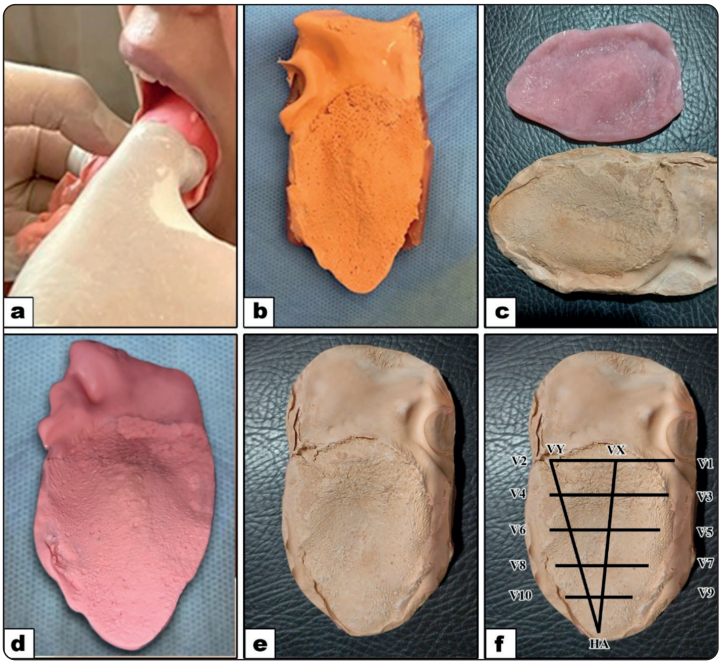

Fig. (4): Taking an alginate impression of the tongue (a & b). Primary cast and special tray (c), final impression and master cast (d & e) for taking the biometric measurements on master cast (f).

Prosthodontist took impression for the tongue by using irreversible hydrocolloid impression material (alginate Cavex ® CA37 fast set) to produce negative imprint of the tongue (fig a & b) which was poured with dental stone to produce the primary caste which was used for constructed a special tray of the tongue (c) to make the final impression of the tongue (d) which poured to produce master cast (e) which was used for taking the biometric measurements (f).

The photographs and the casts were analyzed by three observers separately for the external features including shape, size, color, coating, and presence or absence of tongue fissures and its pattern of distribution. A mean of the observers' measures was taken for every item. Three reference points were considered to determine the shape of the tongue, as clarified before in figure 3.

RESULTS

The tongue shape, size, color and specific features were different among participants in this study. The tongue moistness, movement, and size in relation to the size of the oral cavity. All were normal in the participants in the study (100%).

Tables 1 and 2 demonstrate the tongue measurements in centimeters (cm) in the live photographs and casts of the males and females participants in the study.

TABLE (1) Tongue Length (cm) in male and female participants in the study (Live photographs and Casts)

Tongue Length (Mean ± SD)	Male	Female	p-value
Live photographs	4.2 ± 0.71	3.25 ± 0.57	0.04
Cast	5.31 ± 0.82	4.28 ± 0.46	0.02

Test used: Student T-test, p-value; test of significance, statistically significant P<0.05. SD: Standard deviation, Cm: centimeter.

TABLE (2) Tongue Width (cm) in male and female participants in the study (live photographs)

Tongue Width (Mean ± SD)	Male	Female	p-value
Live photographs	3.09 ± 0.61	2.54 ± 0.75	0.71
Cast	4.09 ± 0.46	3.9 ± 0.42	0.5

Test used: Student T-test, p-value; test of significance, statistically significant P<0.05. SD: Standard deviation, Cm: centimeter.

Figure 5 shows the tongues' shapes, coating, colors, and specific features found in this study participants.

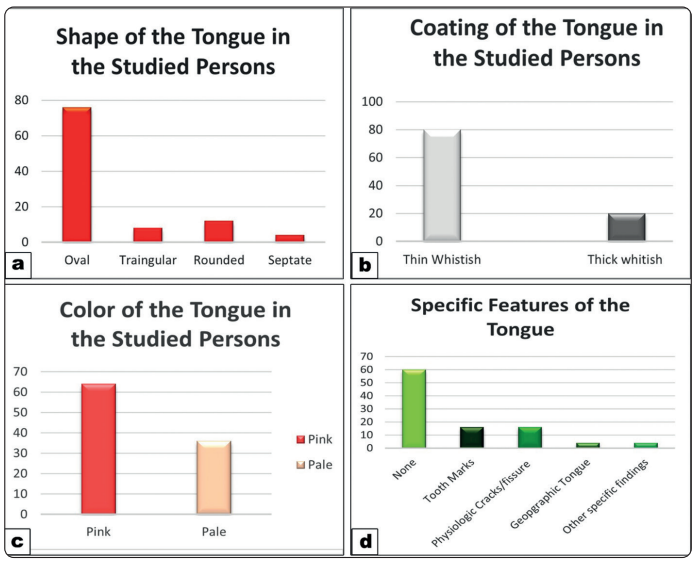

Fig. (5): The tongues' shape, coating, color, and specific features in the study participants.

Tables 3-6 show the tongues' shapes, coating, color, and specific features in the studied male and female persons.

TABLE (3) Tongue Shape in male and female participants in the study.

Tongue Shape	Male (n.= 32)	Female (n.= 68)	p-value
Oval (n. %)	22 (68.75%)	54 (79.41%)	0.26
Triangular (n. %)	8 (25%)	0 (0%)	<0.0001
Rounded (n. %)	0 (0%)	12 (17.65%)	0.01
Septate (n. %)	2 (6.25%)	2 (2.94%)	0.48
Total (n. %)	**32 (100%)**	**68 (100%)**	**100 (100%)**

Test used: Chi Square and Exact Measures of Association, p-value (2-tailed) is significant P<0.05. n.; number, %; per cent.

TABLE (4) Tongue Coating in male and female participants in the study.

Tongue Coating	Male (n. %)	Female (n. %)	p-value
Thin Whitish (n. %)	25 (78.13%)	55 (80.88%)	0.74
Thick Whitish (n. %)	7 (21.87%)	13 (19.12%)	0.74
Total (n. %)	**32 (100%)**	**68 (100%)**	**100 (100%)**

Test used: Chi Square and Exact Measures of Association, p-value (2-tailed) is significant P<0.05. n.; number, %; per cent

TABLE (5) Tongue Coating in male and female participants in the study.

Tongue Color	Male (n. %)	Female (n. %)	p-value
Pink (n. %)	28 (87.5%)	36 (52.94%)	0.0006
Pale (n. %)	4 (12.5%)	32 (47.06%)	0.0006
Total (n. %)	**32 (100%)**	**68 (100%)**	**100 (100%)**

Test used: Chi Square and Exact Measures of Association, p-value (2-tailed) is significant P<0.05. n.; number, %; per cent.

TABLE (6) Specific Features of the Tongue in male and female participants in the study.

Specific Features	Male (n. %)	Female (n. %)	p-value
None (n. %)	13 (40.62%)	47 (69.12%)	0.008
Tooth Marks (n. %)	6 (18.75%)	10 (14.71%)	0.61
Physiologic Cracks/ Fissures (n. %)	11 (34.38%)	5 (7.35%)	0.001
Geographic Tongue (n. %)	2 (6.25%)	2 (2.94%)	0.48
Other specific findings (n. %)	0 (0 %)	4 (5.88%)	0.21
Total (n. %)	**32 (100%)**	**68 (100%)**	**100 (100%)**

Test used: Chi Square and Exact Measures of Association, p-value (2-tailed) is significant P<0.05. n.; number, %; per cent

DISCUSSION

Identification remains a crucial task in Forensic practice [9]. Many body parts are unique for every individual and are helpful in this respect. With the advent of technology, digital methods introduced new ways of using body parts for the purpose of identification. This is in addition to the easy storage, exchange of information and comparison between data of different individuals, using the digital methods [10].

The biometric systems used for identification purposes are the fingerprint, voice print, retinal scan, skin color, palm print, face recognition, signature check, etc. Each of these systems has its own advantages and disadvantages that can make it vulnerable for security break and an interruption in identification purposes [11].

Fingerprints can be eroded, or altered due to surgery or occupational factors, and is prone to injuries and burns, so fingerprints may not remain the same for an individual [12].

Voice is affected by sicknesses such as cold and cough. In extreme emotional states, there are changes of voice and there are misspoken words, making voice prints not accurate in these situations. Retinal scan is highly sensitive, but it is dependent upon the user competency and can be affected by bright light and disease states like cataract and astigmatism [13].

Skin color also is liable to problems in examination and stability as an identification system for individuals. Skin color is liable for considerable differences with age, burns, diseases, and use of skin creams or medications [13].

The tongue print is readily accessible, secure, and a protected organ. It is also a reliable proof of life [6].

In this study, the tongue was examined visually for its external characters of shape, size, color, movement, moistness, and other specific features. Normal tongues were included in the study. Smokers, and persons with systemic or oral diseases or infections were excluded.

We found that the males' tongues were longer than the females' tongues (Table 1). This goes with the findings of **Matsuda et al. (2020)** [14]. However, we did not find a significant difference between males' and females' tongues width (Table 2). This does not agree with what **Singh et al. (2020)** [8] described. The latter authors investigated 15 human males and 15 females in India and reported a significant difference between males' and females' tongues' width in their findings in live photographs examination of the tongue.

On the other hand, **Singh et al. (2020)** [8], found a non-significant difference between males' and females' tongues width in cast measurements; which goes with our findings in this study. We found a non-significant difference between males' and females' tongues width in the casts' measurements.

The measurements obtained from casts were higher in values than the measures obtained from the live photographs. This goes with **Singh et al. (2020)** [8] conclusion regarding live photograph/ casts measurements.

The tongues of the participants in our study showed different shapes. Out of 100 participants, 76 showed an oval tongue, 8 showed a triangular tongue, 12 showed a rounded tongue, and 4 showed a septate tongue **(Figure 5a)**.

Regarding sex distribution of these characters, 79.41% of women in this study showed oval-shaped tongue, with insignificant difference (p=0.26) between females and males (68.75% of males in the study showed oval-shaped tongue).

The triangular shape was seen in males in this study (25% of the male participants), and was not seen in any of the female participants (0%) with a very highly significant difference between the males and females in this respect (p= 0.0001).

On the other hand, the rounded shape was seen in 17.65% of the female participants, and in none of the male participants (0%) in this study, with a highly significant difference between the two (p=0.01).

The septate shape of the tongue was seen in a smaller number of participants in this study (Table 4) with a non-significant difference between males and females participants (p=0.48).

Eighty percent (80%) of the participants in this study showed thin whitish coating of the tongue, and 20% showed thick whitish coating **(Figure 5b),** with non-significant differences between males and females (p=0.74) in this respect (Table 4). Sixty-four per cent (64%) of the participants in this study showed pink tongue, and 36% showed pale tongue **(Figure 5c).** This was observed more in women (47.06% of the participating women) with a significant difference (p= 0.0006) than men (12.5% of the participant men) in this study. A finding that should pay attention to the incidence of anemia/ malnutrition amongst Egyptians mainly in women.

Regarding the specific features of the tongue, 60% of participants showed no specific features, mostly the women (69.12% of women participants) with a significant difference (p=0.008) between men (40.62% showed no specific findings) in this respect. 16% showed teeth marks on the side of the tongue, with a non-significant difference (p=0.61) between men and women participants in this finding. Sixteen per cent (16%) of participants showed physiologic cracks/fissures on the surface of the tongue, more in men (34.38% of men participants) than in women (7.35% of women participants) with a highly significant difference between men and women (p=0.001). Four per cent (4%) of participants showed geographic tongue, with a non-significant difference between men and women (p=0.48). 4% of participants showed special features, e.g., thin mucosa showing red dots reflecting blood vessels on the surface of the tongue **(Figures 1b and 5d)**. They were women, with a non-significant difference to men in this finding (p=0.21).

Our findings do not agree with **Stefanescu et al. (2014)** [15] who studied tongue morphology in Romanian subjects and described that the geographical tongue was characteristic for female subjects, while in our findings in this study on Egyptians, the geographical tongue was reported equally in men and women participants and there was found a non-significant difference between men and women in this observation (p=0.48).

Also, our findings are different from **Zhang et al. (2015)** [16] who studied the shape of the tongue in Chinese people and reported the shape of the tongue in healthy people to be mostly circle or square (86.92% of their sample) followed by triangular and rectangular shapes (9.23% and 3.85% of their sample). In our study, the oval shape was the most reported amongst participants (76% of our sample), then rounded shape (12%), triangular (8%), and septate (4%) of our sample, and we did not report the rectangular shape in our sample of the studied Egyptian participants.

On the other hand, our findings agree with both **Stefanescu et al. (2014)** [15] and **Zhang et al. (2015)** [16] that the different morphological features of the tongue on visual and image-based examinations, confirm the unique features of the tongue for every individual. We, and those investigators, all agree that the tongue carries morphological and structural features that have not been studied to date.

CONCLUSIONS

The tongue is a unique body part which have various static and dynamic features that vary significantly among individuals. The lingual impression can be a helpful and an easy tool for Forensic odontological identification, particularly in the current era with the advent of technology and digital methods. In this study, we found unique length and width measurements of the tongue for every participant, and unique shape, color, coating, surface features of the dorsum of the tongue, that in addition, are different between men and women, thus can help in sex identification. Tongue impressions can used together with methods such as cheiloscopy and rugoscopy (lip print and palate print) in Forensic human identification.

Recommendations and Further Studies

Studies on a larger number of participants and in different centers and locations in Egypt are required to validate these results, build a database for comparison, and to identify other features of the tongue that can be used in Forensic practice and in biometric authentication processes.

There can be further studies on healthy versus disease, and disease versus disease classifications of the lingual impressions using computer-based methods. This means to obtain a database of the tongue measurements and morphology in health and disease states of people of a certain ethnic group. This will be useful for comparison between different ethnic groups, and for the same individual in different stages of life and health/disease statuses [16].

Studying the sublingual vein morphology and its unique shape among individuals can be done using the specific computer programs [17].

The tongue histology provides further unique features for individual identification, and there are no reported studies in our locality about the structural comparison of lingual papillae in cadavers, an issue that is reported in few studies on other population groups [18, 19, 20].

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