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Differences in the morphological structure of the human tongue

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Background: *The tongue exhibits significant individual variability in terms of shape, colour, and surface texture. Due to its location, it is easily accessible for medical examination, although often overlooked. This is due to the inadequate number of studies assessing the morphology of the tongue in the healthy population. Determining the range of normalcy allows for the definition of tongue pathology requiring further diagnostics. The aim of this study is to assess differences in the morphological structure of the tongue in healthy individuals based on existing literature. Morphological structure was evaluated in terms of volume, shape, colour, coating, papillae, texture, and lingual tonsil.*
Materials and methods: *PubMed and ResearchGate databases were included for a thorough analysis of morphological differences in tongue structure.*
Results: *Tongue volume stabilizes by the end of the second decade of life and is closely correlated with BMI. Among the shapes of the tongue, forms such as circular, ellipsoidal, hammer-shaped, in the shape of the letter U, V, or W can be distinguished, and the multitude of these terms results from the lack of a uniform classification. There is agreement regarding tongue colour, with various shades of pink and white being the most commonly observed, while the presence of another colour may indicate disease. The density and size of individual papillae depend on the region of the tongue, age, and the presence of systemic disease. Geographic tongue, hairy black tongue, and fissured tongue are states of papillae pathology. Fissuring of the tongue increases with age, and fissured tongue is more common in men.*
Conclusions: *Differences in the morphological structure of the tongue provide significant information about the health status of each individual. It is necessary to be aware of the physiological changes occurring within the tongue for proper diagnosis.* (Folia Morphol 2024; 83, 2: 262–274)

Keywords: anatomy, fissured tongue, tongue papillae, oral cavity, lingual tonsils

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INTRODUCTION

The human tongue is one of the most important but also one of the least understood structures of our body. Its complex anatomy is one reason for the relative lack of research on it. The tongue exhibits high individual variability in terms of shape, colour, and surface texture [3]. It is unique to our body because it is not a deformable structure and does not contain bones, joints, or air-filled chambers, yet it must move in the oral cavity. It plays a crucial role in many everyday functions of our body, including speech, swallowing, and breathing. It is located at the entrance to the digestive and respiratory systems, enabling it to perform its functions. Thanks to the tongue, we are able to produce speech sounds, consume food, and maintain the patency of the airways [37]. In addition to its participation in physiological functions of the body, the tongue is also an important element in differential diagnosis. This role of the tongue has been particularly appreciated in Traditional Chinese Medicine, where doctors use the tongue to diagnose potential diseases based on such features as colour and texture. In recent years, attempts have also been made to improve computerized or automated tongue diagnosis [17]. The aim of such analyses is to distinguish people with/without a certain disease at an early stage using non-invasive means by utilizing differentiating tongue features [16].

To carry out a detailed analysis of the differences in the morphological structure of the tongue, articles available in PubMed and ResearchGate databases were used. The following keywords were used in the search: tongue, anatomy, oral cavity, fissured tongue, variability, tongue papillae, surface, and colour. Studies published between 2006–2023 were included.

VOLUME OF THE TONGUE

The tongue has a complicated muscular architecture. The literature agrees on the number of muscles that make up the tongue, which are eight, whose fibres interweave with each other, running in three orthogonal directions [3]. While muscles have the greatest impact on the total volume of the tongue, other structures such as connective tissue, especially adipose tissue, blood vessels, and nerves should also be considered. Additionally, the region of the tongue affects the distribution of these tissues. Significant differences in the percentage of muscle tissue (M) and adipose tissue (Ad) in the anterior (Ant) and posterior (Post) parts of the tongue (MAnt vs. MPost; 94.5% vs. 88.9%; AdAnt vs. AdPost; 5.5% vs. 11.1%) were found in adults (n = 20; 18–40 years). Similarly, in the older population (n = 20; > 65 years) (MAnt vs. MPost; 84.4% vs. 80.4%; AdAnt vs. AdPost; 15.6% vs. 19.6%). Comparing older and younger individuals, significant differences were observed only in the percentage of adipose tissue in the total volume of the tongue (old vs. young; 20.1% vs. 8.9%) [28]. The impact of aging on the structural composition of skeletal muscles is well known. With age, there is a gradual replacement of muscle tissue with adipose tissue, leading to a loss of muscle volume and mass [46]. In the study described, a significantly greater proportion of fat was observed in the overall volume of the tongue in older individuals, but there was no loss of tongue muscle volume or mass compared to younger individuals. The relationship between tongue muscle atrophy and fat infiltration remains insufficiently understood because this study was cross-sectional rather than longitudinal. Further research is required to confirm this. The study confirmed that the process of replacing muscle tissue is more intensive in the posterior part of the tongue in both young and older participants [28]. Studies have shown that fatty degeneration is mainly observed in type I muscle fibres [15, 36], and most of the posterior part of the tongue consists of type I fibres [31], confirming that fat infiltration is strongly observed in the posterior part of the tongue. BMI is a parameter closely related to adipose tissue. Among adults, only BMI has a significant positive correlation with the total volume of the tongue, in addition to age and gender [8, 25, 28, 37]. The volume of the tongue gradually increases from intrauterine life to the end of the second decade of life [24].

Differences in the total volume of the tongue observed in studies are not solely due to the factors mentioned above but also to the imaging method and protocol. Magnetic resonance imaging and cone beam computed tomography (CBCT) were used in the analysed studies. The difficulty in calculating the total volume of the tongue arises from the presence of external muscles that have an attachment beyond the proper area of the tongue. Among the analysed studies, magnetic resonance imaging provides the most accurate determination of the volume and boundaries of the tongue muscles. Although there are studies utilizing the same imaging method, the results vary (Table 1).

Although differences in the volume of language between women and men can be observed in all

Table 1. Summary of studies on tongue volume

Study	Imaging method	Number of subjects and sex	Tongue volume [cm^3] (SD)
Kondo et al. [13]	MRI	n = 20 ♀	138.84 ± 16.92
Liégeois et al. [11]	MRI	n = 35 ♂	89.9 ± 11.5
		n = 35 ♀	68.9 ± 7.0
Humbert et al. [14]	MRI	n = 4 ♂	68.0 ± 7.65
		n = 6 ♀	60.25 ± 6.1
Nakao et al. [5]	MRI	n = 10 ♂	20.1 ± 2.3
		n = 10 ♀	18.4 ± 2.4
Ding et al. [10]	CBCT	n = 10 ♂	49.18 ± 7.72
		n = 10 ♀	44.97 ± 6.04
Uysal et al. [15]	CBCT	n = 26 ♂	31.02 ± 9.75
		n = 34 ♀	28.13 ± 8.54

MRI — magnetic resonance imaging; CBCT — cone beam computed tomography; SD — standard deviation.

studies, as mentioned above, the factor significantly affecting the total volume of language is not gender, but height, weight, and BMI. In studies using magnetic resonance imaging, inconsistencies can be observed in determining the muscles belonging to the tongue. In the study by Kondo et al., the volume was calculated as two-thirds of the anterior part, the posterior part of the tongue, the palatoglossus muscle, the palatopharyngeal muscle, and the pharyngeal constrictor muscle [19]. Conversely, Liégeois et al. defined the tongue as all internal muscles, the genioglossus muscle, and the hyoglossus muscle [25]. Humbert et al. included in the total volume of the tongue all internal muscles and only those parts of external muscles (the genioglossus muscle, the hyoglossus muscle, the styloglossus muscle, and the palatoglossus muscle) that enter its body [18]. In Nakao et al.'s study, only internal muscles forming the body of the tongue were considered [28]. In two studies using the CBCT method, variations in volume result from differences in protocols. In the study by Uysala et al., only the surface of the tongue located above the enamel-cementum plane of the lower molars and in front of the frontal plane descending from the posterior nasal spine was measured [42]. In contrast to Uysala's study, Ding et al. included the volume of the tongue located below the enamel-cementum plane [8]. The posterior border of the tongue was determined based on shaded contours of the posterior surface of the oral part of the pharynx. Standardization of the tongue imaging protocol or conducting the study on a larger and more homogeneous group of participants should be considered. This will allow for quantification of differences in tongue volume independent of the age and BMI of the participants.

SHAPE

The morphological aspect of the dorsal surface of the tongue is unique for each individual. The tongue consists of a body, tip, and root, which give it a shape that is not constant but can vary [3]. There are certain difficulties in classifying the shape of the tongue. First, it should be noted that taking a picture of the tongue requires protrusion, and this protrusion often causes the tongue to deviate and tend to shift to one side. Such deviations can disrupt the precise description of features and therefore affect the diagnostic accuracy of the tongue image. Secondly, it is worth noting the difficulty in subjective analysis when defining and presenting by experts what they consider round, elliptical, square, etc. The third important obstacle is changes in the shape of the tongue that do not start and end within 24 hours but can occur and persist for many months, reflecting the course of the disease and thus causing permanent variability, leading to diagnostic uncertainty [17]. In conducted studies, attempts were made to describe the shapes of the tongue that occur in the population, and relationships between gender, age, and its shape were sought. In the study by Madhusudan et al., three tongue shapes were distinguished, comparing them to letters — U, V, and W. It was analysed that the shape of the letter U was observed in the largest number of people (71%), followed by the tongue shape of the letter V (26%), and finally W (3%). Referring the results obtained to individual gender, the shape that dominated in the population also dominated in both genders. However, no significant difference was shown in the occurrence of the same shape more often in women than in men [3]. Surendra et al. distinguished three tongue shapes: hammer-shaped, ellipsoidal, and oval/round. The oval/round shape was most commonly observed (36.7%), followed by the hammer-shaped (33.3%), and finally the ellipsoidal (30%). It should be noted that the percentage differences in the frequency of occurrence of shapes were negligible, which could be influenced by the small number of subjects examined (30 individuals). However, this study showed a relationship between gender and tongue shape. Hammer-shaped was most commonly observed in men (60%), followed by ellipsoidal (26.7%), and oval/round shape (13.3%) was the least frequent. In women, the oval/round shape dominated (60%), followed by ellipsoidal (33.3%), and finally hammer-shaped (6.7%). The author also analysed common shapes of the tip of the tongue, among which he listed pointed, rounded, and septal, which was not observed in any subject. Both in women and men, the tip was most commonly rounded (70%) [38]. Madhusudan et al. also examined the shape of the tip of the tongue, distinguishing pointed, rounded, and septal tips. The study results were comparable, with the rounded shape being dominant (81%), followed by the pointed shape (18%), and the septal shape was observed only in one subject [3]. In the literature, the tongue's shape is described using different classification systems, and the shapes themselves can vary depending on the criteria used. However, the same cannot be said about the shape of the tongue, which is described differently by various authors, most likely due to the obstacles mentioned at the beginning of the paragraph in classifying the shape of the tongue, as well as the varying number of individuals examined.

Observing a lack of coverage in analysed studies, it is worth looking at the work of Bo Huang and colleagues, who presented a classification approach for automatic recognition and analysis of tongue shapes based on geometric features. The elliptical shape is considered the normal tongue shape, but six other classes of tongue shape have been distinguished: square, rectangular, circular, acute triangular, obtuse triangular, and hammer-shaped (Fig. 1) [17].

Further studies should be conducted towards unifying the classification and performing analyses based on it. It should also be considered to examine the tongue not only in the extended position but also in the resting position.

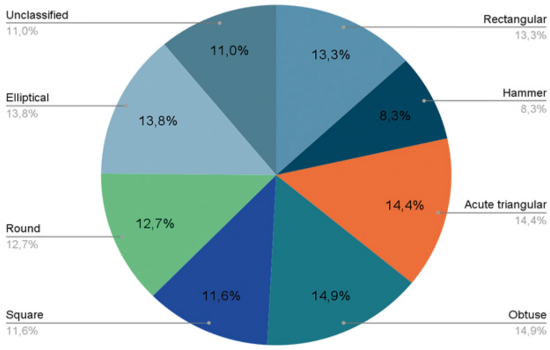

Figure 1. Occurrence of individual tongue shapes in the population of healthy individuals (n = 362) [17].

There are works that link tongue shape with the presence of diseases such as gastric mucosal inflammation manifested by a round tongue, triangular tongue observed in thyroid hyperactivity, and square tongue in ischemic heart disease or portal hypertension. Interestingly, Traditional Chinese Medicine divides the tongue into five regions, the changes of which reflect the condition of individual organs. The left and right lateral regions of the tongue reflect the state of the liver and gallbladder, the tip reflects the state of the heart and lungs, the middle reflects the state of the spleen and stomach, and the base reflects the state of the kidneys [47].

COLOUR

Colour perception is subjective, dependent on individual characteristics. Colour does not exist in reality, but rather the sensation of colour is created in our brains. The colour of the tongue is mainly the result of light reflection and absorption, particularly dependent on internally scattered light. Among the population, there is little awareness that tongue colour can provide useful information about health conditions. Two types of factors influence the diagnosis of tongue colour. First, environmental factors such as sources of light and room temperature, and second, the observer's subjective factors mentioned at the beginning of this paragraph [29]. Among healthy individuals after thorough rinsing of the oral cavity, physiological tongue colours were observed. Surendra et al. observed three main colours: pink, pale pink, and whitish. Among 30 participants, the most

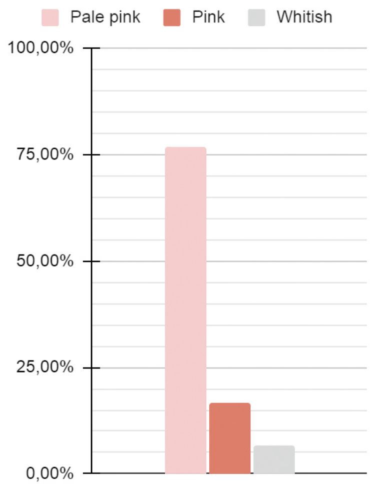

Figure 2. Occurrence of individual tongue colours in the population of healthy individuals (n = 30) [16].

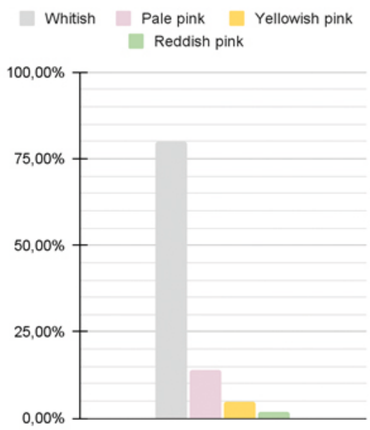

Figure 3. Occurrence of individual tongue colours in the population of healthy individuals (n = 100) [1].

common colour was pale pink (76.7%), followed by pink (16.7%), and whitish (6.7%) (Fig. 2). The relationship between tongue colour and gender was statistically insignificant (p = 0.88) [16]. Madhusudan et al. observed similar tongue coatings with different frequencies. The tongue colours were whitish (80%), light pink (14%), yellow-pink (5%), and pink-red (1%) (Fig. 3). When the distribution of tongue colour was analysed statistically with respect to age and gender, no positive relationship was found. Comparing the literature, we can see similarities in the colours of the tongue distinguished, but the frequency of their occurrence in different individuals was different. The colour of the tongue or its coating can also reflect our health status. A yellow tongue covered with dense moss occurs in people with diabetes. Tongues of cancer patients often have no coating but have a thick, slippery moss and are purple in colour. Individuals with acute ischemic stroke have red, curved tongues with a thick, white moss, features also observed in patients with Helicobacter pylori infection resistant to treatment. The tongue of HIV patients is red and greasy with a thick, white moss. People suffering from primary insomnia also have red and greasy tongues but with yellow and white moss [47]. It is important to note that the tongue should be uniform in colour through whitish to pink-red. Patches, spots and other areas that vary in colour should be further examined [35].

TONGUE COATING

The tongue coating (TC), a naturally occurring layer that adheres to the tongue's dorsum is made up of desquamated epithelial cells, blood cells, metabolites, and bacterial nutrients. Consequently, any variables that hinder the keratinization and death of tongue epithelial cells, infiltration of blood cells, diapedesis of erythrocytes, and complex colonization of microorganisms have a major influence on the development of tongue coating. The primary elements influencing the development of TC are tongue epithelial cells' hyperproliferation, differentiation, and apoptosis [39]. It is important to determine the range of normal thickness and colour of tongue coating among healthy individuals with proper oral hygiene. Tsuchida et al. defined the modified tongue coating index (mTCI), where they classified the thickness of coating descriptively as follows: 0 — no visible tongue coating, 0.5 — a thin layer of coating that can be observed, 1 — visible accumulation of coating with clearly recognizable filamentous and fungal papillae, 1.5 — thicker layer of coating with visible papillae, and 2 — a thick layer of coating without visible papillae. Among the 28 participants, the results ranged from 0 to 1.5, and they also found significantly more biofilm accumulation on the posterior part of the dorsum of the tongue than on the tip [41]. Normal tongue coating is described in the literature as thin, slightly moist, and whitish [33]. It is important to distinguish between the colour of the tongue and the colour of the tongue coating. In a study by Surendra et al. describing the colour of the tongue, participants were asked to rinse their mouth [40]. In the study by Gils et al. that investigated the thickness and colour of tongue coating in healthy individuals, there was no mention of participant

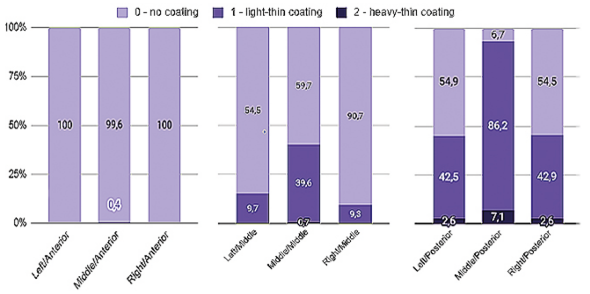

Figure 4. Thickness of the coating depending on the region of the tongue (n = 268) [33].

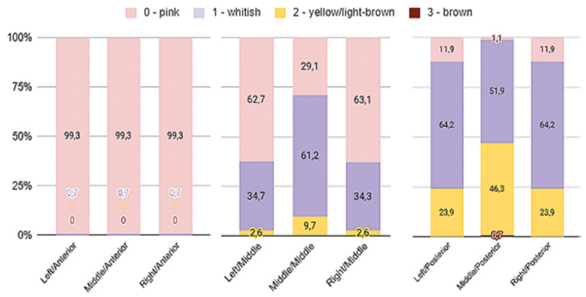

Figure 5. Colour of the coating depending on the region of the tongue (n = 268) [33].

Table 2. Summary of studies on the density of fungiform papillae on the tongue

Study	Examined location	Number of subjects and sex	Mean density of fungiform papillae [number/cm^2] (SD)
Fischer et al. [25]	Tip of tongue	n = 1263 ♀	108.4 (–) (SE = 0.9)
		n = 1108 ♂	97.9 (–) (SE = 1.0)
Zhang et al. [26]	Tip of tongue	n = 182 ♂	96.96 ± 3.06
Correa et al. [23]	Tip of tongue	n = 115 ♀+♂	118.79 ± 13.33
	Body of tongue	n = 115 ♀+♂	61.39 ± 8.53
Karikkineth et al. [27]	Body of tongue	n = 579 ♀	16.14 ± 9.54
		n = 505 ♂	13.77 ± 8.61

preparation. The results of Gils et al. regarding the distribution and thickness of tongue coating are presented in Figure 4 [43].

The tongue was divided into three rows along the longitudinal axis and three along the transverse axis, resulting in a total of 9 areas. The participants were young (18–32 years old) and healthy individuals. The results of Gils et al. work regarding the distribution of tongue colour are presented in Figure 5 [43].

Men had significantly thicker tongue coating and more varied coloration compared to women. In the discussed study, no correlation was found between the thickness and colour of tongue coating with oral hygiene or accompanying gum inflammation. Due to the fairly homogeneous study group, no association with age was demonstrated either [43].

PAPILLAE

There are four types of papillae on the surface of the tongue: filiform, fungiform, foliate, and circumvallate. Filiform papillae serve a mechanical function, while the other papillae contain numerous taste buds and are mainly responsible for the sense of taste. The number of papillae stabilizes at the age of 11–12, only 2–3 years earlier than the end of tongue growth [5]. In this section, the size and density of individual tongue papillae were compared in a population of healthy individuals.

According to the literature, filiform papillae are the most numerous group [32]. However, only one study has reported the density of these papillae at 337–407/cm^2, with lower density observed in the lateral parts of the tongue (337–354/cm^2) compared to the middle parts of the body and the tip of the tongue (390–407/cm^2) [41]. The number of filiform papillae increases with age [43].

The density of fungiform papillae is widely described in the literature, with varying results mainly due to the area of the tongue examined (Table 2).

The density range in the population of individuals without systemic diseases is 0–233.43/cm^2. Significantly higher density of fungiform papillae is present in females, closer to the tip of the tongue, in younger individuals, non-smokers, and those consuming less than four servings of alcohol per day [32]. Fischer et al. also indicated a 40% probability of inheriting the density of fungiform papillae [11].

Foliate papillae are characterized by a significantly smaller number. Their number ranges from 3–20/ /person in studies. Due to their characteristic location, arranged in a V shape in front of the border groove, researchers agree on their number and distribution.

The only factor studied that affects their quantity is gender. In the study by Zdilla et al., women were shown to have 2.22 more foliate papillae than men (M vs. K; 6.26 ± 2.02 vs. 8.48 ± 2.37). There are no studies evaluating the influence of aging and dietary habits on the number of these papillae [48].

The least well-known type are the circumvallate papillae. Located in the lateral-rear part of the tongue, although they contain an average of 30% of all taste buds, they are often overlooked by histology textbook authors due to high individual variability [32]. In the study by Vinubal, their presence was found in 76% of participants [45]. No studies have been found evaluating the total number or density of circumvallate papillae.

Tongue papillae are classified based on their differences in shapes, and there are few studies analysing the variations in size and diameter of circumvallate, fungiform, and filiform papillae in healthy individuals. In the study by Tsuchida et al. with a group of 28 healthy women (19–22 years old), 25% had short filiform papillae ≤ 0.39 mm, 36% had medium-sized filiform papillae 0.40–0.44 mm, and 39% had long filiform papillae ≥ 0.45 mm [21]. The study by Maeda evaluated the relationship between the state of filiform papillae and the occurrence of autoimmune connective tissue diseases. They divided the state of filiform papillae into four types: I — normal pattern with a transparent keratinized tip, II — slight reduction in height with a non-transparent keratinized tip, III — moderate reduction in height without a keratinized tip, and IV — significant reduction in height (flattened pattern). In the healthy group, type I and II were identified in 35 (70%) and 15 (30%), respectively [26]. Similar results were obtained by Dıaz-Gonzalez et al., where type I and II were identified in 41 (82%) and 9 (8%) of the individuals in the control group, respectively [7]. Unfortunately, the studies by Maeda and Dıaz-Gonzalez did not include numerical data on the height of filiform papillae. Variability in morphometry is also present among fungiform papillae. The diameter of these papillae ranges from 0.42–1.15 mm in healthy adults and from 0.35–0.91 mm in children. It has been shown that the diameter decreases linearly with increasing papilla density [30].

Zdilla et al. demonstrated the influence of sex on the diameter of circumvallate papillae. The mean diameter in men was 1.55 ± 0.01 mm, and in women it was 1.28 ± 0.06 mm. Men have a 0.26 mm smaller diameter of circumvallate papillae than women, and as mentioned above, women have an average of 2.22 more circumvallate papillae than men [48]. Changes in density, size, or length of tongue papillae may be a sign of disease or pathological changes. A decrease in the height of filiform papillae may be a result of collagenosis, diabetes, or a deficiency of vitamins B6, B12, E, or iron. Significant elongation of filiform papillae is observed in black hairy tongue [41]. The aforementioned studies by Maeda and Dıaz-Gonzalez et al. showed disturbances in keratinization of filiform papillae in individuals with autoimmune connective tissue diseases, which manifests as a decrease in their height or complete disappearance, as well as the appearance of grooves on the dorsal surface of the tongue. In the study by Dıaz-Gonzalez et al., patterns III and IV were not observed in healthy individuals, while in the group of sick individuals, 12% presented pattern III and 20% presented pattern IV [7]. In the study by Maeda, the state of filiform papillae was evaluated in individuals with connective tissue diseases, mostly Sjögren's syndrome. It was shown that these individuals more often exhibit pathology of filiform papillae, pattern III — 16%, IV — 5%, while no individuals with these patterns were observed in the control group. The height of filiform papillae affects the visibility of the folds of the tongue. The cause is attributed to chronic inflammation surrounding small subepithelial blood vessels [26].

A common, complex, yet not fully established aetiology change is geographic tongue. Geographic tongue, also known as migratory glossitis, is characterized by asymptomatic light and dark patches on the dorsal surface of the tongue. Its prevalence in the population is estimated at 1–2.5%. Familial occurrence of this change has been observed, as well as in individuals with high levels of stress and those with atopic diseases. Chronic subepithelial inflammation, mainly composed of T lymphocytes (CD4+), along with pathological dilatation of small blood vessels, underlie geographic tongue. In the darker spots, a reduction in the density of filiform papillae is observed, while in the white patches, dead cells are present. It often co-occurs with fissured tongue, discussed in the next section of the article [38].

Tongue texture On the dorsal surface of the tongue, a terminal sulcus and a median sulcus have been described. The terminal sulcus is located in the posterior part of the tongue, separating the base from the body. It has a V shape, with the apex of the sulcus directed backward, creating a blind opening (foramen caecus). The median sulcus runs from the aforementioned opening to the tip of the tongue, symmetrically dividing the tongue into left and right parts [32]. One of the most common changes in the tongue described in the literature is a fissured tongue, also known as a furrowed or wrinkled tongue. The cause of this condition has not yet been explained. There are numerous disease syndromes in which this condition is superimposed on the clinical picture, such as Melkersson-Rosenthal syndrome, trisomy 21, diabetes, Sjogren's syndrome, or in individuals after chemotherapy or radiotherapy [21]. The occurrence of this change among individuals without concomitant diseases and more frequently among older individuals appears to contradict the hypothesis of its innate character. There is a view that numerous and deep fissures are caused by the presence of a subepithelial inflammatory state. This inflammatory state is responsible for the atrophy of connective tissue and superficial muscle cells, which contributes to the formation of deep fissures [44]. This view is consistent with Maeda's theory, which is associated with the disturbance of the expression of filiform papillae keratin caused by inflammation in small subepithelial blood vessels [26]. The incidence of this change in the population ranges from 2 to 73.2%, with a large discrepancy resulting from the method of assessing tongue furrowing [10, 14, 38, 44]. Sudarshan et al. proposed a classification of tongue furrowing based on pattern, number, and the presence of accompanying burning sensation. Five patterns of fissured tongue were distinguished: I — central longitudinal, with one median fissure; II — central transverse, with transverse fissures crossing the midline; III — lateral longitudinal, with longitudinal fissures running laterally from the midline; IV — branched, with fissures branching off from the median fissure, V — miscellaneous, with different patterns present. Three categories of frequency were examined: mild, 1–3 fissures; moderate, more than 3; and severe, over 10. A total of 1000 people aged 10 to 80 years were studied. Fissured tongue was observed in 387 individuals, 235 (60.7%) men and 152 (39.3%) women. Pattern I occurred in 50.6%, II — 10.9%, III — 5.2%, IV — 17.6%, V — 15.8%. In individuals with 1–3 fissures, pattern I was most commonly observed (76.9%), followed by II (15.3%) and III (7.8%). In individuals with a moderate number of fissures, 95.7% had pattern IV, and 4.3% had type II. In individuals with a significant number of fissures, pattern V was dominant (96.8%), and pattern IV was 3.2%. Fissured tongue was observed mainly in individuals without concomitant diseases (74.7%) [38]. Hamrah et al. used the same classification. A total of 1182 individuals aged 18 to 80 years were studied, of whom 27.2% had a fissured tongue. The most frequently observed types were type I (42.9%), II (19.6%), III (8.4%), IV (18.9%), and V (10.2%) [14]. Similar to the study by Sudarshan et al., it was noted that fissured tongue occurs significantly more often in men, specifically 7.1 times more often, and most individuals with a fissured tongue did not have accompanying diseases [38]. In the study by Feil and Filippi, 1000 individuals aged 0 to 96 years were studied and divided into 9 age groups. A classification was used to evaluate the location of fissures and the presence of lingual papillae within them: grade 0 — tongue without fissures, grade 1 — lingual papillae visible within the fissure(s), grade 2 — partially smooth flat epithelium (without visible papillae in a maximum of two of three locations, the midline fissure, the lateral fissures on either side of the midline, and the fissures at the edges of the tongue), grade 3 — smooth flat epithelium in all locations. Seven hundred thirty-two individuals had a fissured tongue, which was due to the method of fissure assessment; one fissure visible to the naked eye was sufficient to classify an individual into grade 1. Of those with a fissured tongue, 66.7% were grade 1, 23.6% were grade 2, and 9.7% were grade 3. In the age group of 0–20, more than half of the individuals had a tongue without fissures. The frequency of fissured tongue increased significantly with age. The mean age of individuals with grade 1 was 24.5 years, and for grade 3 it was 66.4 years. Nearly 40% of individuals over 90 years of age had grade 3. Fissured tongue occurred significantly more often in men, smokers, and individuals with a burning sensation in the oral cavity. Alcohol consumption and denture wearing did not significantly affect the occurrence of a fissured tongue [10].

LINGUAL TONSILS

Lingual tonsils are a part of Waldeyer's ring. They are located at the base of the tongue, behind the circumvallate papillae, and are composed of unencapsulated lymphoid tissue. They often occur in childhood due to increased immune activity, but regress in adulthood. Lingual tonsils vary in size and proximity to the pharyngeal tonsil — persistent lingual tonsils may obstruct it in adults. Hypertrophy of the lingual tonsils in adults may be associated with obesity, laryngopharyngeal reflux, younger age, and tobacco smoking. Lingual tonsils are frequently overlooked as a cause of various symptoms reported to an otolaryngologist, such as snoring, persistent cough, or voice changes [4, 6]. Costello et al. classified lingual tonsils based on their appearance and relation to adjacent structures. This classification was named "Swansen Classification" and was divided into 3 grades. Grade 1 — minimally visible lymphatic tissue, undisturbed view of the middle glossoepiglottic fold, visible submucosal vessels, and a tonsillar fossa free of lymphatic tissue, was observed 38 times. Grade 2 with visible lymphatic tissue partially obscuring the middle glossoepiglottic fold and filling the tonsillar fossa was observed 40 times, and grade 3 — reddened lymphatic tissue completely filling the tonsillar fossa and obscuring the middle glossoepiglottic fold and/or invading the epiglottis — was observed 42 times. In a group of 100 examined individuals, 25 patients reported symptoms of lingual tonsil pathology such as sore throat, dysphagia, fever, lethargy, eye socket sensation, speech change, earache, submandibular pain, obstructive sleep apnoea, chronic cough, shortness of breath, or choking on food [6]. The complete otolaryngological examination with endoscopy was also conducted in the study by Çoban K et al. [4]. They used the following classification of lingual tonsil hypertrophy: grade 0 — absence of lingual tonsil tissue, grade 1 — scattered lingual tonsil tissue with visible vascularity at the base of the tongue, grade 2 — scattered lingual tonsil tissue with limited vertical thickness and no visible vascularity on the tongue, grade 3 — lingual tonsils covering the entire base of the tongue with vertical thickness ranging from 5 to 10 mm and/or invisible grooves, grade 4 — lingual tonsil tissue with vertical thickness ≥ 1 cm and/or invisible epiglottis. The study included 119 patients, with a control group of 42 healthy individuals, including 22 women (52.4%) and 20 men (47.6%). According to the classification, grade 0 was observed in 17 (40.5%) subjects, grade 1 in 13 (31.0%) subjects, grade 2 in 9 (21.4%) subjects, and grade 3 in 3 (7.1%) subjects. The study group included individuals with allergic rhinitis, of which 48 (63.6%) were women and 28 (36.4%) were men. Grade 0 was observed in 10 (13.0%) individuals, grade 1 in 24 (31.2%) individuals, grade 2 in 22 (28.6%) individuals, and grade 3 in 21 (27.3%) individuals. From the presented results, it can be deduced that the presence of lingual tonsil hypertrophy was more common in the study group than in the control group. Grade 0 was significantly more often observed in the control group than in the study group, while grade 3 was significantly higher in the study group than in the control group. This study demonstrated a positive correlation between allergic rhinitis and lingual tonsil hypertrophy. However, this study had some limitations, such as the method of identifying lingual tonsil hypertrophy — endoscopy, which is a subjective method. The solution to this problem could be the use of computed tomography or magnetic resonance imaging [4]. Friedmann used computer tomography to measure the thickness of the lingual tonsil tissue in both healthy patients and those with risk factors for pharyngeal tonsil hypertrophy, such as laryngopharyngeal reflux (LPR), obstructive sleep apnoea-hypopnea syndrome (OSAHS), or both factors combined. In the healthy group, the average thickness of the lingual tonsil tissue was 0.9 mm, while in patients with LPR it was 3.5 mm, with OSAHS it was 4.55 mm, and in the group suffering from both LPR and OSAHS it was 3.08 mm. It was demonstrated that LPR may be the cause of lingual tonsil tissue hypertrophy, which in turn may contribute to the development of OSAHS. The study results indicate that the average thickness of lingual tonsil tissue in patients with LPR and/or OSAHS is significantly greater than in healthy patients. However, further research is necessary to determine the typical values of lingual tonsil tissue thickness in healthy individuals and those with different age groups [12].

PHYSICAL EXAMINATION AND TONGUE DISEASES

As explained in previous chapters, knowledge of the differences in the morphological structure of the tongue enables proper diagnosis of tongue pathology. Below is presented a protocol for the physical examination of the tongue, as well as a compilation of tongue diseases with their localizations and symptoms (Table 3). In the protocol below, we excluded neurological tongue assessment as the routine part of the cranial nerves examination.

Patient preparation

Ensure proper lighting in the examination area to facilitate visualization. It is vital to perform check-ups in the same lighting. Penlights may be useful in viewing posterior aspects of the tongue.

Table 3. Summary of tongue diseases

Geographic tongue (Benign migratory glossitis)	[35]	The dorsal margin of the tongue	Filamentous papillary hyperplasia — in form of irregular light or dark patches, which may have a white border. The patches might change location over time
Candidiasis a) Middle rhomboid glossitis	[27, 34]	The midline dorsal aspect of the tongue	Disappearance of the papillae in the form of a red or white spot
Hairy tongue	[27]	2/3 anterior dorsal part	Hyperkeratosis and elongation of filiform papillae — dark discoloration of the tongue, furry or hairy appearance
Atrophic glossitis	[34]	Entire tongue	Erythematous tongue, lack of the lingual papillae and a smooth, shiny, dry appearance, atrophic tongue
Hunter's Glossitis (Glossitis in vitamin B12)	[20]	The dorsal margin of the tongue	Lingual atrophy with diffuse erythema, the surface is smooth, devoid of papillae, as if varnished
Strawberry tongue	[34]	The dorsal of the tongue	Persistent hypertrophic fungiform papillae
Tongue cancer a) squamous cell carcinoma b) Kaposi Sarcoma	[13, 27]	in 2/3 of cases it develops in the front part of the tongue in 1/3 of cases it develops in the root of the tongue a) posterior lateral and ventral surface of the tongue b) the dorsal margin of the tongue	Persistent sore or lump on the tongue. Localized pain, dysphagia, weight loss, dysarthria, and odynophagia are also common a) exophytic masses or endophytic and indurated ulcers b) plaques or tumours of coloration ranging from non-pigmented to brown-red or violet
Lichen Planus	[2]	The dorsal margin of the tongue	White, net-like lines or white patches
Oral hairy leukoplakia	[27]	Lateral aspect of the tongue	Hyperkeratotic, corrugated or hairy white plaques
Leukoplakia	[27]	Ventral surface of the tongue	Adherent, white plaques

Patient positioning

Ask the patient to sit comfortably in an upright position. Instruct the patient to open their mouth wide and protrude their tongue.

Visual examination

Observe the tongue's overall appearance, size, and shape. Note any abnormalities in colour, texture, coating, or lesions.

Systematic assessment

Examine the dorsal surface of the tongue. Note the colour, presence of any coating, and any abnormalities such as papillae, fissures, or ulcers. Examine the ventral surface of the tongue. Assess for colour, texture, and any lesions or abnormalities. Check the lateral borders of the tongue for any irregularities or lesions.

Palpation

With gloved hands, palpate the tongue gently to assess for any areas of tenderness or induration. Pay attention to any palpable masses or abnormalities beneath the tongue's surface [22].

Mobility

Check mobility of the tongue, ask patient to:

- stick out their tongue as far as possible — this assesses the ability of the tongue to extend forward;
- pull their tongue backward toward the throat — this tests the tongue's ability to retract;
- moves their tongue from side to side, touching each corner of the mouth with the tip of their tongue — this evaluates lateral movement;
- touches the roof of their mouth with the tip of their tongue — this assesses the upward movement of the tongue;
- lowers their tongue to the floor of the mouth — this evaluates the downward movement of the tongue;

Observe and note any limitations, deviations, or compensatory movements during these tasks.

TONGUE DIAGNOSIS IN TRADITIONAL CHINESE MEDICINE AND EVIDENCE-BASED MEDICINE

In this chapter we provided a brief comparison of the tongue diagnosis in Traditional Chinese Medicine (TCM) and Evidence-Based Medicine (EBM).

The only visible similarity may be seen in tongue examination. Both TCM and Western medicine use tongue examination as part of their diagnostic process. They observe the colour, shape, size, coating, moisture, and other characteristics of the tongue.

Differences appear in the following:

1. Interpretation: In TCM, the tongue is believed to reflect the overall health and balance of the body's organs and systems. The appearance of the tongue is associated with specific patterns of disharmony in TCM, such as excess or deficiency of qi (vital energy), blood stasis, or dampness [20]. In contrast, Western medicine primarily focuses on specific conditions and diseases rather than assessing overall organ or system imbalances through the tongue.
2. Diagnostic approach: TCM practitioners often use tongue diagnosis as part of a holistic assessment, considering other symptoms, medical history, and pulse diagnosis [1]. In contrast, Western medicine typically relies on a combination of medical history, physical examination, laboratory tests, and imaging techniques to make a diagnosis. The tongue examination in Western medicine is usually a part of a comprehensive assessment.
3. Scientific evidence: Western medicine places a strong emphasis on evidence-based medicine, relying on rigorous scientific studies to support diagnostic and treatment decisions. There is limited scientific evidence to support the use of tongue diagnosis in TCM as a standalone diagnostic tool. Although some studies have explored the relationship between tongue characteristics and certain health conditions [1].
4. Treatment implications: In TCM, the interpretation of the tongue's appearance guides the selection of acupuncture points, herbal remedies, and other TCM interventions to restore balance and treat underlying disharmonies [20]. In Western medicine, the tongue examination is more likely to be used as a supplementary diagnostic tool to help to undertake treatment decisions.

The integration of tongue diagnosis in traditional Chinese medicine (TCM) and Western medicine to form a standardized system is a topic of ongoing exploration and discussion. Some researchers and practitioners advocate for integrating objective measurements, such as digital imaging, spectroscopy, or computerized analysis, to provide more quantifiable and reproducible data during tongue examination. This approach aims to enhance the reliability and consistency of tongue diagnosis, aligning it with the principles of evidence-based medicine [47]. By integrating standardized measurement techniques and incorporating the diagnostic criteria of both TCM and Western medicine, it may be possible to develop a more unified and standardized system for tongue diagnosis. This could involve establishing specific guidelines for evaluating tongue characteristics, such as colour, shape, coating, and texture, and their correlation with various health conditions. However, it's important to note that developing a completely standardized system is a complex task due to the inherent differences in the underlying philosophies and diagnostic approaches of TCM and Western medicine. Achieving a full integration would require extensive research, consensus building, and validation through rigorous scientific studies.

CONCLUSIONS

The tongue is a unique organ of our body in many ways. A properly understood physiology of the tongue provides important information about the health status of every human being. The morphological structure of the tongue shows a wide range of normality, which is particularly important information for dentists observing this organ in their daily practice or for doctors evaluating the tongue during a routine physical examination. It is necessary to strive for standardization of the classification of morphological features of the tongue, for further analysis of the topic of this study. Understanding the physiological differences in the structure of the tongue will allow for expanding research towards identifying tongue pathology in the form of deviations from the norm.

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