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Tongue coating and tongue brushing: a literature review

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Abstract: The present paper reviews the role of the tongue as a habitat for oral microorganisms and the potential need for tongue cleaning as part of daily oral hygiene. In addition tongue coating is described. Many microorganisms have been found colonizing the dorsum of the tongue. Some studies find a positive effect to tongue brushing on bacterial counts on the tongue. On the other hand there are also studies that do not find any differences in bacterial counts before or after tongue brushing. Bacteria colonizing the tongue and periodontal pockets play an important role in the production of volatile sulphur compounds in periodontal health and disease. These compounds can be the cause of oral malodour. The amount of tongue coating in patients complaining of halitosis was significantly greater than in patients without halitosis. Tongue brushing on a regular basis, particular aiming at removing the coating on the dorsum of the tongue, has been found to be fruitful in reducing oral malodour. Studies investigating the role of tongue brushing and plaque accumulation or gingival inflammation show conflicting results. It is clear that the tongue forms the largest niche for microorganims in the oral cavity. However, on the basis of literature, there appears to be no data to justify the necessity to clean the tongue on a regular basis. One exception would be oral malodour.

Key words: tongue coating; tongue brushing; microorganisms

Introduction

The papillary structure of the tongue dorsum forms a unique ecological oral site that provides a large surface area favouring the accumulation of oral debris and microorganisms (1, 2). Tongue microorganisms may contribute to dental plaque formation (1, 3). Although there is a continuous shedding of tongue epithelium, Sarrazin (4) showed that the dorsum of the tongue is hardly ever free from staphylococci and streptococci. These microorganisms

can comprise up to 90% of the bacterial mass on the tongue. It has been suggested that tonsils, teeth and gingiva can be colonised by tongue bacteria, which originate especially from the posterior region. Daily tongue cleaning was therefore recommended, stating that the best time for it was in the morning on an empty stomach, so that vomiting ensued or gagging occurred (4). For centuries, tongue hygiene has been routinely practiced by many eastern and oriental cultures (5). In western countries over the last few decades, little attention has been paid to tongue hygiene. In traditional Chinese medicine, inspection of the tongue is an important method of making medical diagnoses and determining prognosis. It can be traced back to rudimentary tortoise shell and bone inscriptions dating from the 16th century BC. Many articles and books on tongue coating have been published, and two more recent papers give a review of traditional Chinese tongue inspection (6, 7). However, as all referenced literature is in Chinese, it is difficult to grasp the true scientific value of this diagnostic method.

The appearance of the dorsum of the tongue is variable. Normally, it is either pinkish or has a thin white coating (7), and the elderly are more likely to have a discoloured tongue because of change of diet, decrease in salivary flow and their inabilty to cope with oral-hygiene methods (5). The thickness of the tongue coating can vary as well. It seems that subjects with periodontal disease are more likely to have a thick layer of coating compared to subjects with healthy periodontal tissues (8, 9).

The purpose of this paper was to review the role of the tongue as a habitat for oral microorganisms as well as the potential need for tongue cleaning as part of daily oral hygiene.

Tongue coating

Tongue coating comprises bacteria, large amounts of desquamated epithelial cells released from the oral mucosa, leukocytes from periodontal pockets, blood metabolites and different nutrients (8–10). Microscopic research on the tongue's ultrastructure has shown that formation of the tongue coating is closely related to the rate of multiplication of epithelial cells and the quantity of desmosomes and membrane-coating granules (6).

For a number of reasons, the elderly patient is more likely to exhibit a coated tongue than the younger patient. Change in dietary habits, inability to physically cope with oral-hygiene techniques, a decrease in the salivary flow and change in the nature of the saliva will all lead to accumulation of oral debris and its deposition on teeth, supporting tissues and the dorsal aspect of the tongue (11). Furthermore, there is a decrease in fungiform papillae and increase of filiform papillae with age (6). It has been suggested that the tongue-coating volume tends to increase in cases with periodontal involvement. Leukocytes are increased in saliva of patients with periodontal disease and accumulate on the tongue surface (9, 10). In a study by Gómez *et al.* (12), the extent of a white coating on the dorsum of the tongue was greater in periodontitis patients compared to periodontally healthy patients. Salivary flow rate appeared not to affect the accumulation of tongue coating in patients with periodontal disease (9).

De Boever and Loesche (13) observed differences in total colony forming units (CFU) of the tongue in patients with presence or absence of tongue coating. Tongues with deep fissures were found to have higher number of CFU in samples taken from the tongue as compared to patients with smooth tongue surfaces. Contrastingly, Quirynen *et al.* (10) and Gómez *et al.* (12) did not find a relation between the total number of CFU on the tongue and the presence or absence of tongue coating. There also appeared to be no relation between different tongue surface profiles (fissures or no-fissures) and the total number of CFU on the tongue. No differences have been found in the prevalence of black-pigmented colonies (suggestive for *Porphyromonas* or *Prevotella*) in samples taken from coated and non-coated tongue surfaces (8).

Measurement of the tongue coating

Several methods have been described to measure the extent of tongue coating. Yaegaki and Sanada (8) suggested a method to measure the tongue coating, which reads as follows: '. . . The tongue coating was carefully removed with a tongue scraper of the small spoon type, from the terminal sulcus to the apex of the tongue, then the tongue dorsal surface was cleaned with cotton pellets immersed in physiological saline. After removal of the tongue coating, the wet weight of the tongue coating was estimated (mg). . .'. Gross *et al.* (14) used an index (0–3, i.e. no coating to severe coating); however, neither a clinical description nor photographs were given to visualise such an index. Bosy *et al.* (2) estimated the amount of coating on the tongue's dorsal surface by visual examination as heavy, medium, light or none. Miyazaki *et al.* (15) assessed the tongue-coating status according to the distribution area: score 0, none visible; 1, less than one-third of tongue dorsum surface covered; 2, less than two-thirds; and 3, more than two-thirds. Chen (7) classified the tongue coating by colour (white, yellow, grey and black) and by quality of the tongue (dry, slippery, dry and rough, prickly, partially furred, completely furred).

As is obvious from the preceding paragraph, several methods to assess the tongue coating have been proposed, but none of them seem to provide an exact method to score it. Recently, a new tongue-coating index has been described by Winkel *et al.* (16). The dorsum of the tongue was divided into six areas, i.e. three in the posterior and three in the anterior part of the tongue. The tongue

Fig 1. Discolouration of the tongue: score 0, pink; score 1, yellow/light brown; score 3, brown; score 4:, black.

coating in each sextant was scored as 0 = no coating, 1 = light coating and 2 = severe coating. The discoloration of the tongue was scored in the same sextants and scored as 0 = no discoloration, 1 = light discoloration and 2 = severe discoloration.

Recently, Gómez *et al.* (12) investigated the intra- and inter-examiner reproducibility of assessing tongue coating and discoloration according to a well-described modification of the method introduced by Miyazaki *et al.* (15). For this index, the tongue was divided into nine parts. For each of the nine sections, discoloration and coating was visually assessed. The discoloration was scored on a scale from 0 to 4 (0 = pink, 1 = white, 3 = brown and 4 = black) and the thickness of coating was scored on a scale from 0 to 2 (0 = no coating, 1 = light-thin coating and 2 = heavy-thick coating). On average, approximately 70% intraexaminer agreement for discoloration and coating was obtained between two assessments 1 week apart. The percentage of agreement between the examiners for the assessment of discoloration was lower as compared to the thickness of coating. On average, 50% agreement was found for discoloration and 58% for thickness of coating. Figure 1 shows samples of tongue-coating discoloration.

The dorsum of the tongue as a habitat for microorganisms

Krasse (17) found that *Streptococcus salivarius* comprised a large proportion of the facultative streptococci present in saliva and on the tongue, while this organism included only a small percentage of dental plaque streptococci. As a result of these and other studies, it was suggested that a large proportion of bacteria present in saliva emanate from the tongue. The significance of oral mucosal surfaces as a habitat for the microbes has also been investigated using an experimental gingivitis model. The presence of motile organisms and black-pigmented *Bacteroides* on the dorsum of the tongue and tonsils was found to be correlated with the presence of these microorganisms in a 23-day-old dental plaque. It was concluded that, in particular, the mucosa of tongue and tonsils may harbour periodontopathic microorganisms and may possibly function as a nidus for these bacteria (3).

As has been mentioned earlier, the tongue harbours and sheds many microorganisms each day. Investigators of the source of salivary microorganisms conclude that a large proportion of salivary microorganisms emanate from the tongue, and, in general, the microorganisms of the tongue influence the flora of the entire oral cavity (1, 18). Many microorganisms have been found colonising the tongue. In the following paragraphs, microorganisms frequently described in connection with periodontitis and caries are evaluated in relation to their presence on the tongue.

In periodontitis patients, *P. gingivalis* can be detected in saliva, on the dorsum of the tongue, tonsils, buccal mucosa and gingiva, and other mucous membranes (19). This organism is usually absent or present in low numbers in periodontally healthy individuals (20, 21). In an Indonesian population (15–25 years of age)

that had not received periodontal treatment, *P. gingivalis* was present in 63% of samples from the tongue, in subjects with or without attachment loss (22).

Prevotella intermedia can colonise the oral cavity at an early age (23; Frisken *et al.* 1990). It has been isolated from oral mucous membranes, from saliva and from supra- and subgingival plaque (19). In the young adult Indonesian population, *P. intermedia* was detected in 99% of tongue samples (22). In a western population without clinical attachment loss, *P. intermedia* was found in approximately 80% of the tongue samples (24). This species has also been recovered in relatively high numbers from the majority of the tongues and tonsils of patients with periodontal breakdown (25).

In generalised juvenile periodontitis patients, *A. actinomycetemcomitans* has been recovered from the subgingival samples and the tongue; however, on the tongue, the frequency has been much lower as compared to the deepest periodontal pocket (26). In adult periodontitis patients, *A. actinomycetemcomitans* has been detected in 55% of the samples taken from the dorsum of the tongue, when the microorganism was also present in subgingival sites (27). In the Indonesian young adults, *A. actinomycetemcomitans* was detected in 25% of the tongue samples (22).

Prevotella melaninogenica, *P. loescheii* and *P. denticola* are found on the tongue of both periodontally healthy and periodontally diseased subjects, and are regarded as normal colonisers of the oral cavity (3, 25, 26, 28).

Eikenella corrodens is frequently isolated from subgingival dental plaque samples in adult periodontitis patients (29). *E. corrodens* is also recovered from other oral sites in these patients (30, 31). *Capnocytophaga* are also colonisers of the oral cavity and more frequently recovered from the tongues of non-diseased persons compared to periodontal patients (20). The presence of *Streptococcus mutans* in the oral cavity differs. Their presence in the dental plaque is correlated with dental caries. Their presence in saliva is considered to influence and contribute to the presence of these microorganisms on the tongue (32, 33). When the number of CFU in saliva increases, the number of CFU on tongue increases as well. *Odontomyces viscosus* has its habitat among the filiform papillae of the tongue, coating the dorsum of the tongue with a viscous, white, non-adherent material (34). Root caries in patients above age 50 is primarily attributed to *O. viscosus*. The yeast *Candida albicans* has been found on the tongue as well, and is a member of the commensal oral microbiota with an estimated prevalence in the human population of 30–40% (35). Furthermore on the tongue, spirochaetes and other motile organisms have been recovered often in patients with periodontal breakdown, while in periodontally healthy patients, these species have not been recovered (25).

Wolffe and Van der Velden (36) found that in the course of 1 day, the percentage of motile microorganisms on the dorsum of the tongue undergoes considerable changes. Also, intraindividual variations in the percentage of motile microorganisms in the course of a month were observed by Van der Weijden and Van der Velden (37). Based on these two studies, it was concluded that the composition of the bacterial flora on the dorsum of the tongue varies within time.

It was found that on the tongue of smokers, the number of Neisseriae was smaller compared to that of non-smokers, and that it harboured more *Bacteroides* and *Veillonellae* [38]. An experimental gingivitis study was conducted in a group of young subjects, of which 11 were smokers and 14 were non-smokers. The results showed that there were no qualitative differences in the microbiology of the tongue between smokers and non-smokers. Quantitatively, the total number of CFU at baseline measurements was higher for non-smokers as compared to smokers (24). A dramatic fall in the oxidoreduction potential (Eh) occurs in the floor of the mouth and in the buccal surface of the upper molars after smoking one cigarette (39). This and probably other factors could influence the microflora in the oral cavity.

Tongue coating and malodour

Although oral malodour has multiple aetiologies, the most common type is caused by the degradation of protein, peptides and amino acids by microorganisms residing on the tongue and tooth surfaces (10). Much more volatile sulphur compounds, H_2S and methyl mercaptan, are produced on the dorsal surface of the tongue in patients with periodontal disease. Bacteria colonising the tongue and periodontal pockets play an important role in the production of volatile sulphur compounds in periodontal health and disease (9, 10, 13, 15). As many as 82 oral species have been shown to produce fatty acids, H_2S and methyl mercaptan from cysteine and methionine, but no single organism has been implicated as the primary cause of oral malodour (40). In people with rigorous oral hygiene, clean and intact dentition and a healthy periodontium, the source of bad breath is likely to be the dorsum of the tongue. Although the anterior part of the dorsum of the tongue usually smells, the main source of odour is usually the posterior part of the dorsum of the tongue. Malodorous microorganisms such as *P. gingivalis*, *Fusobacterium* sp., *P. intermedius and Capnocytophaga* sp. are present (2, 41). In the elderly, *Odontomyces viscosus* organisms have their normal habitat amongst the filiform papillae of the tongue and take over or replace *Streptococcus viridans* at about 70 years of age. These inhabit the tongue in particular and produce a viscous coating with malodorous components on it (11, 34).

The relation of tongue-coating and oral malodour has been the subject of many studies. Delanghe *et al.* (42) found that in 87% of the patients with oral malodour, the cause was of oral nature. Of these oral causes, 51% were because of tongue coating, 17% a result of gingivitis, 15% a result of periodontitis and 17% a result of combinations. In a study by Oho *et al.* (43), it was stated that the amount of tongue coating in patients complaining of halitosis was significantly greater in the halitosis-positive group compared to the halitosis-negative group. Morita and Wang (44) investigated the relationship between sulcular sulphide level and oral malodour in subjects with periodontal disease. The volume of tongue coating and the percentile of sites with bleeding upon probing were significantly associated with oral malodour. In a study by Quirynen *et al.* (10), the effect of a 1-stage full-mouth disinfection on oral malodour and microbial colonisation of the tongue in periodontitis patients was investigated. The baseline organoleptic ratings and the volatile sulphur compound (VSC) scores correlated well with the presence of tongue coating. No correlation was found between tongue coating and the total number of CFU on the dorsum of the tongue. Therefore, it was concluded that tongue coating *per se* and not the bacteria might be responsible for malodour. Also in a study by Miyazaki *et al.* (15), a significant correlation was observed between the VSC value and the periodontal conditions and the tongue-coating status. In this study, 2672 subjects of the general population were included (18–64 years). Their results suggest that oral malodour might be caused mainly by tongue coating in the younger generation and by periodontal diseases together with tongue coating in older cohorts in the general population. Delanghe *et al.* (42) evaluated experiences of a Belgian multidisciplinary breath odour clinic. The volatile sulphur compounds were measured in all patients, and it appeared that tongue coating was the most frequent cause of malodour.

Yaegaki and Sanada (9) studied biochemical and clinical factors influencing oral malodour in periodontal patients and demonstrated that (i) the concentration of disulphide increased in proportion to the total pocket depth; (ii) 60% of the VSC was produced from the tongue surface; (iii) the amount of tongue coating was four times greater than in control subjects. This suggests that not only microorganisms but also tongue coating is a factor enhancing VSC production in patients with periodontal disease.

Tongue brushing

Tongue cleaning has been used since antiquity and is still used by natives of Africa, Arabia, India and South America. Hygiene of the tongue has in the past been considered as an important part of oral hygiene (45). Many ancient religions emphasised cleanliness of the entire mouth, including the tongue. The Indians' daily ritual of oral hygiene was confined not only to brushing of the teeth, but the tongue was also scraped, and the mouth was rinsed with concoctions of betel leaves, cardamom, camphor or other herbs. Tongue scraping and brushing have been practiced for hundreds of years, but they are still little appreciated or used by the public in western countries. Throughout the centuries, tongue scrapers have been constructed of thin, flexible strips of woods, various metals, ivory, whalebone, tortoiseshell and plastic (45). Tongue cleaning is a simple and fast procedure that helps to remove organisms and debris from the tongue. When tongue cleaning is practiced on a daily basis, the process becomes easier. Eventually, the person feels unclean when tongue debris has not been removed (45). In the last decades, the tongue has been neglected because of the need to concentrate on the protection and treatment of the hard dental tissues and their supporting structures.

Methods of tongue cleaning

Tongue cleaning can be carried out by using a modern tongue-scraping instrument that is available and that consists of a long strip of plastic ribbon, which is held in both hands and bent so that the edge can be pulled down over the dorsal surface of the tongue removing the coating (Fig. 2). It has also been mentioned that the inverted bowl of a spoon may be used as a substitute for the commercial variety of tongue scrapers. Brushing also appears to be an easy method of cleaning the tongue, provided that the gagging reflex can be controlled. Massler (34) advised that the practice of regular tongue brushing should be initiated in the elderly as soon as the tongue shows signs of developing a thick white mucoid coat, which persists after breakfast. However, he suggests that the earlier the cleaning of the tongue is commenced in life, the easier it will be to control the gagging reflex (11).

Suggestion for the tongue-cleaning procedure (taken from Christensen; 46):

- Place the tongue as far out of the mouth as possible.
- Observe the location of the debris accumulation. Unfortunately, the debris is usually on the most posterior aspect of the dorsum of the tongue.
- Place the tongue cleaner/scraper as far posterior as possible, and apply force on the scraper to flatten the tongue, making sure that it will make contact with the whole of the tongue. Many persons gag at this time, and practice is required to find the right positioning of the implement and to minimise the gag response.
- Pull the tongue cleaner forward slowly to the front of the mouth.
- Remove the debris from the cleaning device by placing it under a stream of running water.
- Repeat the scraping procedures several times until further debris cannot be removed.

Fig 2. Different types of tongue scrapers.

- Clean and dry the cleaning device and store it until the next use.

Tongue brushing not only improves the clinical appearance, but will also reduce bacterial populations (47). In a study by Gross *et al.* (14), the test group was instructed to brush their tongue in addition to their normal oral-hygiene measures. The control group was not allowed to do so. A reduction in the presence of tongue coating was found of 40% in the test group as compared to the control group.

Tongue brushing and plaque accumulation

Some studies have shown that tongue brushing in combination with other methods of oral hygiene is an effective method in reducing the formation of dental plaque (1, 47). In contrast, Badersten *et al.* (48) found no difference in plaque accumulation between a 4-day period of tongue brushing and a 4-day period of no oral hygiene procedure. Also, when toothbrushing was compared with a combination of tooth and tongue brushing for 1 week, differences in plaque accumulation were not established. Badersten *et al.* (48) suggest that the majority of the important plaque-forming bacteria might not originate from the tongue. Another reason for not finding an effect of tongue brushing on plaque formation may be that brushing of the posterior part of the dorsum of the tongue is difficult because of inaccessibility and discomfort.

Tongue brushing and gingival inflammation

In the study conducted by Jacobson *et al.* (1), no significant reduction in gingival inflammation after tongue and palate brushing in combination with regular oral hygiene was observed. A trend was observed towards reduction in the gingival index of all participants, as the study progressed. This was explained by the frequency of oral prophylaxis performed on the participants throughout the study. It could also have masked any effect that tongue and palate brushing had on reducing gingival inflammation.

Tongue brushing and oral malodour

Some studies show that tongue brushing and tongue cleaning diminishes the percentage of volatile sulphur compounds in patients suffering from malodour (2, 49). Removal of the tongue coating markedly reduces both volatile sulphur compounds production and the H_2S/methyl mercaptan ratio, not only in orally healthy subjects but also in patients with periodontal disease (9, 10). The average reduction in oral malodour after tongue brushing ranged from 59 to 88% (49). These results indicate that the tongue, and not the plaque, as suggested by some investigators, appears to be the principal source of oral malodour (H_2S). It is quite possible, however, that dental plaque may play a more significant role in subjects with periodontal disease who emit a more disagreeable mouth malodour.

Tongue brushing and taste sensation

In a review article, it is suggested that tongue brushing is especially important for increasing taste acuity in geriatric patients who receive prostheses, because a dry mouth cannot distinguish the subtle flavours of good well-prepared food (50).There is, however, only one study available which evaluated

taste sensation after tongue brushing (51). In this study, each subject attended several sessions to test different flavours, i.e. sucrose, NaCl, citric acid and caffeine. In one session, the tongues of the participants were cleaned with a new toothbrush and in another session the tongue was cleaned with toothbrush and dentifrice. The results showed that in young subjects, the use of dentifrice decreased taste perception for sucrose. Both tongue-cleaning procedures decrease the sensitivity for citric acid. Tongue brushing alone decreased caffeine thresholds and increased NaCl thresholds. The older subjects were affected similarly by both tongue treatments with a major influence of the dentifrice on caffeine thresholds. It was concluded that the brushing of the tongue with or without dentifrice affected taste-perception thresholds.

Effect of tongue brushing on the microbiology of the tongue

Large quantities of plaque bacteria can be present on exfoliated epithelium from the tongue (52). Subjects who habitually brushed their tongue had less daily variation in total bacterial and streptococcal counts on their tongues than non-tongue brushers (47). Tongue brushing for 2 weeks has been shown to reduce the total number of all streptococcal species from both the tongue and natural dental plaque (53). Menon and Coykendall (54) stated that the number of streptococci recovered from the swabs of the tongue varied among the 22 subjects studied, but mostly were between 10^6 and 10^7. Although tongue scraping may impart a feeling of cleanliness and health to its practitioners, their investigation indicates that the procedure does not significantly reduce the population of streptococci on the tongue.

Van der Velden *et al.* (55) evaluated the effect of mechanical cleaning of the dorsum of the tongue and the prevalence of *P. intermedia* and motile organisms in superficial and deeper layers of the tongue. The results showed that even after extensive mechanical cleaning of the tongue, *P. intermedia* and motile organisms could still be recovered and that 2 weeks of mechanical cleaning of the tongue showed no effect on the prevalence of *P. intermedia* and motile organisms on the tongue.

Dawes *et al.* (56) investigated four different oral-hygiene regimes and the output of bacteria into human whole saliva. The four regimes were: (i) rinsing with water; (ii) eating a meal and toothbrushing; (iii) a thorough dental prophylaxis and (iv) tongue brushing and scraping. No differences were found in effects of the four procedures in terms of bacterial counts. It was stated that various oral hygiene procedures have similar effects on the number of bacteria in saliva.

Summary

This review aimed at searching for an evidence-based advice on whether habitual cleaning of the tongue should be part of daily oral-hygiene procedures. It is clear that the tongue forms the largest niche for microorganisms in the oral cavity. On the basis of the literature, there appears to be no data that justify the necessity to clean the tongue on a regular basis. One exception would be oral malodour. It has become clear that in those cases the presence of a tongue coating is an important factor. Subsequently, when there is a complaint of oral malodour, tongue brushing on a regular basis, particularly aiming at removing the coating on the dorsum of the tongue, has found to be fruitful.

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