OPEN ACCESS

Saudi Journal of Medicine

Abbreviated Key Title: Saudi J Med
ISSN 2518-3389 (Print) |ISSN 2518-3397 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Review Article

Improving Toothbrush Hygiene: Handling Toothpaste Residue

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DOI: 10.36348/sjm.2021.v06i06.006 | **Received:** 01.05.2021 | **Accepted:** 08.06.2021 | **Published:** 20.06.2021

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Abstract

Tooth brushing using toothpaste and the toothbrush remains the most common mouth cleaning method. Many dentists recommend the use of a fluoride-containing toothpaste twice daily when tooth brushing. This process retains food debris, blood, crevicular fluid, saliva, phlegm and toothpaste residues in between the bristles of the toothbrush if not thoroughly cleaned after use. These can potentially infect traumatic injuries caused by toothbrushes in the mouth and also re-infect immunocompromised persons after recovery from some illnesses or other persons when toothbrushes are shared or improperly stored. Household vectors attracted to toothpaste residues on toothbrushes can potentially infect such toothbrushes with non-endemic strains of microorganisms as well. With hundreds of millions of people around the world projected to join the class of the extremely poor by 2021 as a result of the COVID-19 pandemic, one popular professional recommendation for toothbrush hygiene- replacement every 3 or 4 months- is increasingly likely to be ignored. This paper recommends additional, cost-effective, universally adaptable ways of improving toothbrush hygiene for the removal of toothpaste residues after tooth brushing.

Keywords: Toothpaste, residue, toothbrush, hygiene.

INTRODUCTION

Tooth brushing is a part of our daily personal hygiene measures and it is learnt in childhood and practiced throughout life, especially for the dentate patient. While some dentists will suggest that tooth brushing should be done after every meal, it is generally recommended by dentists that tooth brushing be done at least twice daily. The American Dental Association, ADA (2005) recommends brushing twice daily with a soft toothbrush and a fluoride toothpaste for two minutes each time since this has been shown to be effective in plaque removal (Creeth *et al*, 2009), reducing the risk of caries and aiding tooth remineralization (Newby *et al*, 2013). Toothbrushes used with toothpastes are the most commonly used tooth-cleaning devices (Shah *et al*, 2018, Logaranjani *et al*, 2015). Electric or manual toothbrushes are available. Some of the electric toothbrushes are of the sonic variety.

When used to brush the teeth, tooth brushes get in contact with blood, toothpaste, saliva, food debris, crevicular fluid (Warren *et al*, 2001) and phlegm when the oropharyngeal inlet is cleaned too. These may encourage the growth of micro-organisms which are either endemic or alien to the normal micro-flora of the user's mouth when kept in storage, ready for the next use. Such contaminated toothbrushes have been shown to harbor and transmit viruses and bacteria (Warren *et al*, 2001). In healthy adults, contamination of toothbrushes occurs early after initial use and increases with repeated use (Bonten *et al*, 1996, CDC, 2016). It has been recognized that while simple measures to improve toothbrush hygiene, including the recommendations of the ADA (2005), will generally suffice to reduce the microbial counts on toothbrushes, remnant micro-organisms from the individual's mouth have the potential to infect traumatic injuries in the mouth. The ADA (2005) and CDC (2016) acknowledge that significant risks are not posed to individuals' local and systemic health by micro-organisms from the flora native to their mouths. However, immune-compromised and vulnerable people may remain susceptible to serious re-infection by organisms from their own toothbrushes (Bunetel *et al*, 2000).

DISCUSSION

The emphasis on the need to consider the toothbrush as a source of potential pathogens in today's world of organ transplantations and alterations in the immune system (Ankola, Hebbal, & Eshwar, 2009) and the fact that people often traumatize themselves with their toothbrushes (Glass & Lare, 1986) show that toothbrush-inflicted wounds may produce potential portals of entry for microorganisms through these mucosal breaches. In addition, toothbrushes may become infected with organisms foreign to the toothbrush owner's flora by sharing personal toothbrushes, having toothbrushes belonging to different people make contact when kept in storage after use and when aerosols which are generated and carried in the air by flushing the toilet after use with the toilet seat cover left open, settle allowing the deposition of such fecal microorganisms including coliform bacteria (Alber, 2015; American Society of Microbiology, 2015) on the tooth brushes. This is more likely when, as is commonly practiced, toothbrushes are left out to dry, after use, in bathrooms, especially shared ones. Non-endemic opportunistic Pseudomonas species have been demonstrated on bristles of toothbrushes which were covered with plastic caps after use, instead of being left out to dry (Mehta, Sequeira & Bhat, 2007). Frazelle and Munro (2012) also documented the contamination of covered freshly used tooth brushes which were covered. Other potential sources of 'non-endemic' organisms include those carried by ants and "house geckos" resident in most homes in tropical Africa, Australia, Middle East, southern parts of the United States and in many other countries in South and Central America and South Asia (Rodder, Sole & Bohme). These vectors are attracted to the taste of toothpaste residues left on toothbrushes after brushing (Adenuga, 2017). In addition, tooth brush hygiene practices which encourage users to run their fingers through the bristles as they rinse their brushes may infect these brushes with non-endemic organisms if the hands are not washed prior to tooth brushing after prior contact with contaminated surfaces.

It is therefore desirable that after tooth brushing, the toothbrush is cleaned free of these materials to improve tooth brush hygiene (ADA, 2005; Warren *et al* 2001, Kahn 2014).

In recognition of the infective potential of tooth brushes which are in use, recommendations on toothbrush hygiene have been made, including those of the ADA (2005) and CDC (2016). These bodies have recommended the individual use of toothbrushes by persons without sharing, to prevent the exchange of bodily fluids and microorganisms (Bunetel *et al*, 2000) and replacing toothbrushes every three to four months or if they have frayed bristles or at the beginning and end of any illness including the common cold. Other common recommendations include rinsing toothbrushes after use and leaving them out to dry in an upright position in areas exposed to sunlight, preferably outside the toilet, the use of disposable, single-use toothbrushes, keeping toothbrushes belonging to different people apart from each other when in storage and proper storage of toothbrushes in current use while in transit as well as the boiling of toothbrushes in hot water (Kahn, 2014). Of tooth brush care, Kahn (2014) says, "Some run it through the dishwasher. Others soak the head in mouthwash or effervescent denture cleaner. Still others freeze it, boil it or invest in a pricey ultraviolet toothbrush sanitizer." However, some of these methods, including the recommendation to use microwave ovens, often lead to toothbrush damage (CDC, 2016). Keeping toothbrushes in solutions of Listerine, Hydrogen Peroxide (Ankola, Hebbal & Eshwar, 2009), Chlorhexidine or Triclosan-containing toothpaste (Warren *et al*, 2001) have also been recommended. Other scientific efforts aimed at improving toothbrush hygiene include the use of ultra-violet "sanitizers" and the use of toothbrushes with bristles coated or sprayed with agents with antimicrobial action-CPC-Cetylpyridinium chloride, a quaternary ammonium compound (Meier *et al* 1996) or chlorhexidine (Mehta, Sequeira, & Bhat, 2007; Hamal *et al*, 2014) to significantly reduce bacterial load, although Al-Ahmad *et al* (2010), did not find any improvements in antimicrobial effects against residual bacteria present on toothbrush head.

However, it has been advised that it is essential that the normal flora of the mouth should not be completely removed from toothbrushes, so as not to allow the proliferation of opportunistic organisms such as fungi and viruses (Kahn, 2014).

Another recommendation (Warren *et al*, 2001) adds that dental professionals should advise patients who have systemic, localized or oral inflammatory diseases to disinfect or frequently replace their toothbrushes. Oral-B has designed brushes and brush heads which contain blue Indicator^{R} bristles which fade, to signal when to replace them and the Oral-B CrossAction^{R} Vitalizer Plus (Gillette/ Procter & Gamble, U.S.A.) toothbrushes which feature antimicrobial bristle protection to help keep brush bristles clean in between brushing for up to 90 days, although these brushes are not guaranteed to kill bacteria in the mouth and protect the user against disease or from being sick. These toothbrushes are expected to be changed in roughly three months, which is the generally recommended time for changing toothbrushes, when the former's indicators fade and the latter's advertised antimicrobial bristle protection feature expires. A toothpastes such as the Crest Pro-Health (Procter & Gamble, Greensboro, NC, U.S.A), discourages bacterial growth due to its Stannous fluoride content and should theoretically, also exert some residual antibacterial action in toothpaste residues on toothbrushes.

Leaving toothbrushes out to dry for about twenty-four hours should significantly reduce the remnant moisture content and microbial load on used toothbrushes, regardless of the ambient humidity. However, if tooth brushing is done using the same brush at least twice daily, as is generally recommended by dentists, then the drying time which significantly reduces the remnant microbial load on the tooth brush cannot be achieved.

However simple these recommendations may be, a sense of attachment to one's toothbrush may keep the brush in use beyond the replacement period of three or four months recommended by the ADA (2005) and the CDC (2016), especially if in the user's judgment, the brush still appears satisfactory and effective. This may be true even for those who can easily afford to replace their toothbrushes routinely, while many poor people may consider the three-monthly toothbrush replacement recommendation an unaffordable expense. In addition, individuals who use at least two brushes concurrently at different locations, one at work at an outstation and another at home, may also choose to keep their tooth brushes for longer than the recommended period for replacement.

Moreover, a good quality tooth brush, manual or electric, will appear expensive whether as a single-use, disposable type or as one to be replaced as recommended. This must be considered to be out of the economic reach of the preponderance of dwellers of sub-Saharan Africa and in other developing countries around the world, who are among the over 700 million poor people currently living on less than two US dollars per day (<$2USD/day), with the COVD-19 pandemic expected to push an additional 88 million to 115 million people into extreme poverty to as many as 150 million by 2021 (The World Bank, 2020). Malekafzali *et al* (2011) have also recognized that the cost of replacing toothbrushes at frequent intervals may be prohibitive in underdeveloped countries. Therefore, more persons are likely going to be using their toothbrushes for longer than the recommended period.

Toothbrushes are usually used with tooth pastes, most of which are pleasantly-flavored and formulated to give fresh breath. These toothpastes are also shown in television advertisements (Logaranjani *et al*, 2015) displayed as generous applications leaving the viewers with the impression that large volumes, rather than the smear or pea-sizes recommended by dentists are ideal. Hence, many users of toothpastes will exude more toothpaste than is necessary (Creeth, Bosma & Govier, 2013) either by doing so very slowly to achieve dispensing a single, large volume of toothpaste for their use or by using two brush head lengths, exuded continuously, to-and-fro, to achieve this or even reloading the toothbrush with more toothpaste even when no falling off of the toothpaste from the toothbrush has occurred before actual toothbrushing commences. The excessive ingestion of toothpaste in childhood has been associated with fluorosis (Nessa, 2018) of teeth while a case of excessive ingestion of toothpaste by an adult, resulting in osteofluorosis, has also been reported (Roos *et al*, 2005).

The immediate consequence of this over-dispensing is the tendency for excess toothpaste to be dislodged away from the toothbrush even before effective tooth brushing is commenced. Dispensing and using excess quantities of toothpaste rapidly produces an uncomfortable foamy fullness of the mouth and, in the case of spicy toothpastes, a burning discomfort on the tongue and oral mucosa which may encourage quick spitting. This has the tendency of discouraging complete brushing of the teeth for the recommended minimum of two minutes brushing time. Another consequence is the deep penetration of the toothpaste between the bristles once the overloaded brush is pressed against the teeth at the commencement of tooth brushing. This leaves more toothpaste residues than if smaller quantities of toothpastes are dispensed. The closer the excess toothpaste is to the embedded ends of the bristles of the toothbrush, the more difficult it becomes to remove all toothpaste residues from the brush by rinsing under a running tap or running a finger through the bristles at the conclusion of the tooth brushing exercise. It is expected that toothbrushes with frayed bristles (possibly occasioned by chewing as is common with children) will retain toothpaste residues which will resist easy removal by simply rinsing. Toothbrushes which have more rows (as many as five) in their widest areas will also retain more residual toothpaste. Brush heads which allow wider spacing between the rows of bristles will also allow for easier removal of toothpaste residues.

When toothpaste residues remain on tooth brushes after tooth brushing, inspissation takes place as the tooth brush is left to dry out as is generally recommended by dentists, making it harder to remove such residues later. When an individual uses different toothbrushes concurrently, such as using one at home and another at an outstation, the chances of leaving dried, inspissated residues of toothpastes between the bristles at their bases in the toothbrush head, are high. Using high pressure running water, preferably warm or hot, will significantly remove toothpaste residues from the brush if used immediately at the conclusion of the brushing exercise. But if this act is delayed till the next brushing time, it will also soften the nylon bristles of the brush especially if done before tooth brushing, casting some doubts on the subsequent efficacy of the excessively softened bristles in cleaning the teeth. Unfortunately, many families in developing countries do not have access to running hot water, or even room temperature water, inside their homes.

Attempting to rid the tooth brush of toothpaste residue after it becomes inspissated, rather than just

after brushing, turns out to be less successful using running water from a tap. Inspissated toothpaste residue could contain microbial organisms from blood, food debris,phlegm and saliva and crevicular fluid as well as micro-organisms from other sources such as those carried by vectors such as domestic sugar ants and "house geckos" which may be attracted to toothpaste residues on toothbrushes. It is imperative therefore that toothpaste residues be removed from toothbrushes at the end of tooth brushing when it is easier to remove than when the toothpaste residue becomes inspissated. Using hot water to remove the toothpaste residues after inspissation at the time of the next brushing exercise will unfortunately soften the bristles of the brush excessively, rendering them less effective during that use. Placing the toothbrush under a running tap of hot water under reasonable pressure is very effective in removing residues of toothpaste from the toothbrush and the bristles would have regained their firmness before the next use of the toothbrush. Unfortunately, readily available hot and/or cold tap water remains inaccessible to a large number of persons living in developing countries.

RECOMMENDATIONS

It is being recommended by the authors that hands be washed first before picking up the toothbrush and toothpaste container to prevent contamination. Next, we recommend that, in addition to actually using only pea-sized or smear applications of toothpaste for brushing, tooth brushes should be rinsed after brushing, under a running tap of hot, warm or cold water (or from a cup if running water is unavailable), a clean finger (usually the thumb) should be run through the bristles to free up food debris trapped in it, then the brush head be turned horizontally on its long side and a strong stream of air blown from the brush owner's mouth to push toothpaste residues through the rows of bristles to the other side of the brush head This may be less successful with round toothbrush heads with concentric circular arrangement of bristles, usually used with electric toothbrushes but is very effective with manual tooth brushes. The toothbrush is then placed under the running tap in the same position to completely remove all toothpaste residues. If no running water is available, the toothbrush is then dipped into another cup of clean water, with at least sufficient water to cover the immersed toothbrush head and shaken in it to remove all the residual toothpaste. A second similar rinse with clean water should remove any excess toothpaste from the base of the bristles of the brush. Sharply shaking the toothbrush removes more water from the toothbrush for faster air drying of the toothbrush bristles.

In addition, the authors recommend the daily use of two (2) tooth brushes per person, one for use in the mornings and the other for use in the evenings to allow enough time for adequate and proper drying of the toothbrushes (and the attendant significant reduction in the residual microbial counts seen after about twenty-four hours). Toothbrushes should also be routinely and periodically examined by the owner or supervising adult(in the cases of children and the mentally retarded) for evidence of frayed bristles, indicating the need for replacement even if this occurs before or after the routinely recommended three-month replacement period.

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