



## TOOTHBRUSH CONTAMINATION AND SANITIZATION: A NARRATIVE REVIEW

### Dental Science

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### ABSTRACT

**Introduction:** Brushing is generally considered to be a primary oral hygiene aid to effectively remove plaque. The contamination of toothbrushes occurs from a plethora of microorganisms that colonize the oral cavity as well as from the environment in which they are stored. **Need for study:** The contaminated toothbrushes serve as the source of disease transmission and re-infection of the patient. Toothbrushes are often stored in toilets/bathrooms, providing an optimal warm and humid environment for these microorganisms to thrive. Prolonged use of toothbrushes can lead to colonization of *Streptococcus mutans*, *Staphylococcus aureus*, *Pseudomonas*, *Lactobacilli*, *Klebsiella*, and *Candida* which cause dental caries, gingivitis, stomatitis and other general health problems such as bacteremia, septicemia, infective endocarditis, arthritis, gastrointestinal, respiratory, and renal problems have also been documented. **Review:** According to the American Dental Association (ADA), toothbrushes should be changed every 3 months. Decontamination of toothbrushes with chemical agents (Chlorhexidine gluconate – 0.2%, Listerine, Plax, Sodium hypochlorite 1%) significantly decreases the bacterial load. Newer sanitization methods such as microwave radiation and UV light have also been tried. Studies show that microbial count was lower in toothbrushes that have microwave radiation than in the UV group. The study highlights the various factors that affect the contamination of toothbrushes and their role in disease transmission. This systematic review sheds light upon the various scientifically tried decontamination interventions and summarizes the effectiveness of each intervention. **Conclusion:** The lack of awareness regarding toothbrush disinfection amongst all age groups is a major public health concern. Oral and systemic diseases can be significantly controlled by reducing the bacterial load in the oral cavity. This can be done by appropriately storing, disinfecting, and replacing toothbrushes periodically.

### KEYWORDS

toothbrush , sanitization , bacteria , contamination

### INTRODUCTION

Maintenance of proper oral hygiene is essential for good oral health. Dental plaque is a highly specific variable structural entity formed by sequential colonization of microorganism on tooth surface, epithelium and restorations. It allows for the co-aggregation of a wide spectrum of microorganisms that compete with indigenous oral flora of the mouth to cause disease. It is also involved in causing dental caries and periodontitis. Plaque control methods can be of two types: mechanical (toothbrushes, dental floss, interdental brush) and chemical (mouthwashes, toothpaste). Toothbrush is the most dependable mechanical aid used for effective plaque removal, preventing dental caries and other oral diseases. Toothbrushes become contaminated by the oral flora, contaminated environment and hands, storage containers, aerosols from flushing toilets etc. They can become infected with *Streptococcus mutans*, *Staphylococcus aureus*, *Pseudomonas*, *Lactobacilli*, *Klebsiella*, *Candida* and *E. coli*[1]. These contaminated toothbrushes then act as a source of disease transmission and reinfection of the oral cavity. They can lead to dental caries, gingivitis, stomatitis and other general health problems such as bacteremia, septicemia, infective endocarditis, arthritis, gastrointestinal, respiratory, and renal problems<sup>[2]</sup>.

To prevent these diseases, toothbrush disinfection is necessary. Decontamination of toothbrushes with chemical agents (Chlorhexidine gluconate – 0.2%, Listerine, Plax, Sodium hypochlorite 1%) significantly decreases the bacterial load. Newer sanitization methods such as microwave radiation and UV light have also been tried but the best method is yet to be reviewed. The aim of this review was to determine the various factors causing toothbrush contamination and evaluate the efficacy of several methods of disinfection.

### REVIEW

#### FACTORS AFFECTING TOOTHBRUSH CONTAMINATION ENVIRONMENTAL FACTORS

Since the fetus develops in a protective environment, the oral cavity is devoid of bacteria at birth, but soon it is accustomed to many microbes[3]. It can be caused by exposure to a contaminated environment that contains various microorganisms or by changes in children's food habits during their growth. Toothbrushes are usually stored in warm and humid environments as bathrooms with attached toilets get infected by aerosols from flushing toilets. Studies show that aerosol can travel up to a distance of 6 to 8 feet hence the areas in the

vicinity of toilets can still be in danger of contamination<sup>[4]</sup>.

Dayoub et al. reported that toothbrushes stored in closed containers or those which are exposed to contaminated surfaces produce a higher number of bacteria than those left in aerated rooms<sup>[5]</sup>. Mehta et al concluded that capped toothbrushes are more prone to contamination with potentially pathogenic microorganisms such as *Pseudomonas* which can lead to oral diseases<sup>[6]</sup>.

#### TOOTHBRUSH DESIGN

Successful marketing strategies of companies influence people to buy more expensive, attractive looking or most familiar toothbrushes. These fancy toothbrushes do not always provide optimal cleaning of teeth. Awareness should be created amongst the community to help them select toothbrushes based on important parameters of toothbrush design. Microbial growth on toothbrushes varies depending on their bristle's length, material, number, anchoring as well as the design of the handle. The various types of bristle designs available in the market are flat, multilevel, rippled, crisscrossed, spiral, tapered etc. The areas in which tufts are attached to the toothbrush are particularly susceptible to contamination<sup>[7]</sup>. The capillary action can pull liquids and food waste into the spaces between the tufts, resulting in increased microbial growth<sup>[8]</sup>. In their carefully designed study, Willi-Eckhard Wetzell et al found that a new method of anchoring toothbrushes i.e individual in-mold placement of filaments makes retention of bacteria difficult as the filaments are anchored in the mold individually, hence there is more space between filaments which makes rinsing easier<sup>[9]</sup>. In the study by Rosenberg et al, the smooth handle had markedly reduced microbial contamination juxtaposed to the grooved handle toothbrush as total DNA count and endotoxin levels were significantly less on the smooth handle<sup>[10]</sup>. Some toothbrushes have a tongue scraper at the back of the head of a toothbrush which further aids bacterial retention<sup>[15]</sup>.

#### AGENTS

Aerobic bacteria, anaerobic bacteria, and polymicrobial flora were isolated from used toothbrushes<sup>[11]</sup>. Toothbrushes used by both healthy individuals and by patients with oral infection were colonized by pathogenic microorganisms such as *Staphylococcus aureus*, *Pseudomonas*, gram-positive rods, and yeast<sup>[12]</sup>. Glass demonstrated the presence of Herpes Simplex Virus 1 on toothbrushes which could remain active for up to 7 days and cause infection in an individual<sup>[13]</sup>.

Microorganisms isolated from toothbrushes stored in bathrooms without attached toilets include *Streptococcus mutans*, *Lactobacilli*, *Pseudomonas*, *Klebsiella*, *Streptococcus pyogenes*, *Staphylococcus aureus*, *Candida*, and *E.coli* were found from toothbrushes kept in bathrooms with attached toilets.

*Streptococcus mutans* and *Lactobacilli* are involved in the initiation and progression of dental caries; *Pseudomonas* leads to eye infections and UTIs; *Klebsiella* causes pyogenic infections, septicemia, and pneumonia; *Streptococcus pyogenes* causes glomerulonephritis and rheumatic fever; *Staphylococcus aureus* causes boils, pustules, and endocarditis. *E. coli* is known to cause disorders like diarrhea, UTIs, septicemia, *Candida* causes candidiasis<sup>11</sup>.

**HOST FACTORS**

The oral cavity provides a warm and moist environment for microorganisms to flourish. The dental plaque allows for the colonization of wide spectrum of microorganisms that compete with indigenous oral flora of the mouth to cause disease. Toothbrushes are used as primary mechanical aid for the effective removal of plaque and hence have greater chances of becoming contaminated with prolonged usage. Toothbrushes used for longer than 12 weeks revealed the presence of *Pseudomonas* and *Sphingobacteriales*, which are seen in dental biofilms.

The age of the patient also plays a significant role in the contamination of toothbrushes. *Lactobacillus* species were primarily found in large numbers in toothbrushes of younger age groups in contrast to the actinobacteria which was seen in ages between 15 to 76<sup>14</sup>. Toothbrushes of individuals with oral diseases such as gingivitis and other periodontal diseases get infected more rapidly than those of healthy individuals<sup>12</sup>. When saliva is added from patients with low or high cariogenic activity, the adherence of bacteria to toothbrushes is significantly increased. Saliva adheres to the toothbrush due to its viscosity and capillary action and aid in the colonization of bacteria<sup>15</sup>.

**STERILIZATION TECHNIQUES  
CHEMICAL AGENTS**

Toothpaste and chemical agents such as chlorhexidine mouthwash, hydrogen peroxide, *Brushtox*, *Dettol*, *Listerine*, sodium hypochlorite, *Plax*, and Herbal products like 3% neem, 5% turmeric have been effective in reducing microbial load. The use of chlorhexidine-coated toothbrushes is also considered a means of prevention of toothbrush contamination<sup>16</sup>. Several studies were conducted to identify the efficacy of chlorhexidine. Soaking toothbrushes overnight in 0.2 % chlorhexidine solution reduced the bacterial count more significantly than *Listerine* due to its broad spectrum antimicrobial effect<sup>16,17</sup>. This is an economical and easy-to-use method for decontamination. Another study demonstrated soaking brushes in an ozone-saturated phosphate-buffered saline (PBS) solution for 30 mins effectively reduced contamination. The limitations of this study were that a low dose of ozone was used so prolonged exposure was required to attain maximum sanitization<sup>18</sup>.

**NEWER METHODS OF TOOTHBRUSH SANITIZATION**

Recent studies show the use of microwave and UV light as effective way to disinfect toothbrushes. A significant reduction in bacterial load is seen using both procedures. However, microwave radiation has shown better results than UV light.<sup>19</sup>

Gujjari et al. reported that contaminated toothbrushes are sanitized when exposed to microwave radiation<sup>20</sup>. Data suggests that microwave-induced eradication of microorganisms is mainly caused by the thermal effect of microwave exposure resulting in cell lysis<sup>21</sup>. Cells damaged by heat result in leakage of nucleic acid and proteins. A study reported that microwave-injured cells often release ninhydrin-positive material, purines, pyrimidines, and ribonucleotides into the suspension medium indicating damage to the cell membrane<sup>20-22</sup>.

UV Light toothbrush sanitizer is considered to be an effective, nontoxic, and easy-to-use method for toothbrush disinfection. UV light disrupts the chemical bonds holding the DNA together, and if the damage is extreme, bacteria can not heal themselves and are inactivated<sup>23</sup>. According to Boylan et al<sup>24</sup> UV light toothbrush holders can reduce bacterial contamination by 86 % whereas Gujjari et al. found a reduction of 42 % in the microbial count after irradiation with UV Light<sup>19</sup>. Hence, further research is required to identify the efficacy of UV light. The most important limitation of this disinfection method

is that UV radiation of low intensity is ineffective against bacteria. Studies also show that prolonged subjection to UV light is also required for the complete sanitization of toothbrushes. The area where the bristles are tightly packed into the toothbrush is also difficult to decontaminate<sup>19</sup>.



Ward SB, Sanchay C, Anant F, Krogge T, Singhal A. Microbial contamination of toothbrushes with different principles of filament anchoring. J Am Dent Assoc. 2001; 132(9):738-41.

STUDY	AIM	DESIGN	SAMP LE	RESULT
Dayoub et al (1977)	To determine the degree of bacterial contamination of toothbrushes after contamination and storage in closed containers or in the air.	Experimental	N=103	Toothbrushes stored in closed containers or those which are exposed to contaminated surfaces retain a higher number of bacteria than those left in aerated rooms.
Glass and Jensen (1994)	To determine the effects of different toothbrush designs and UV sanitation on microbial contamination.	Experimental	N=72	Microbial growth on toothbrushes depends on their bristle's arrangement, material, design etc. A UV light sanitizes toothbrushes.
Wetzel et al (2005)	To evaluate microbial contamination of toothbrushes depending on different principles of filament anchoring.	Experimental	N=120	Out of the 3 techniques examined, individual in-mold placement of filaments made the retention of microorganisms more difficult.
Mehta et al (2007)	To evaluate the effectiveness of covering a toothbrush with a cap.	Experimental	N=10	Capped toothbrushes are more prone to contamination with potentially pathogenic microorganisms such as <i>Pseudomonas</i> which can lead to oral diseases.
Karibasappa et al (2011)	To investigate microbial contamination in toothbrush heads stored in bathrooms with or without attached toilets.	Experimental	N=40	<i>Streptococcus mutans</i> , <i>Staphylococcus aureus</i> , <i>Pseudomonas</i> , <i>Lactobacillus</i> , <i>Klebsiella</i> , and <i>Candida</i> species were isolated. <i>Escherichia coli</i> was found in bathrooms with attached toilets.

Gujjari et al (2011)	To evaluate the efficacy of domestic microwave oven and commercial ultraviolet (UV) light toothbrush sanitizer.	Experimental	N=30	Microwave radiation was more effective in reducing microbial load than UV light toothbrush sanitizer.
Schmidt et al (2014)	To determine the influence of time, toothpaste and saliva in the retention of Streptococcus mutans and Streptococcus sanguinis on different toothbrushes.	Experimental	N=4	Saliva promotes increased adherence of bacteria to the toothbrushes. there was a decrease in the number of microorganisms with increasing dry storage time.
Rosenberg et al (2017)	To evaluate the difference in toothbrush contamination with smooth and grooved handle.	Experimental	N=26	The smooth handle toothbrush had significantly less bacterial contamination compared to the grooved-handle toothbrush.

### DENTALAIRFORCE HOME CLEANING SYSTEM

It is an FDA-approved device that can work as an alternative to typical dental care including brushing, flossing and oral irrigation. The dental air force uses water, air and powder cleaner. The cleaner removes greasy plaque, and reduces the acid environment of the oral cavity. This device also provides the benefits of flossing by aerating the spaces between teeth and water cleans the teeth by washing away food debris and bacteria. A neutral environment is achieved due to the presence of a buffering agent, sodium bicarbonate in the cleaner. This device can be effectively used in patients using orthodontic appliances and bridges.

### CONCLUSION

Based on this systematic review, the following conclusions were made :

The absolute lack of awareness regarding how toothbrush becomes contaminated, their storage, and disinfection among all age groups is a major health concern. Children in schools should be educated about toothbrush contamination and disinfection along with the proper brushing techniques. Young mothers should be made to realize the significance of sanitizing brushes regularly. Myths such as costly and more complicated looking toothbrushes clean teeth better should be eradicated. It should be brought to public knowledge that contamination is lowest in soft and round, clear, two bristle row toothbrushes. Toothbrushes should always be stored in open aerated conditions. Maximum toothbrush contamination is seen after 12 weeks of use. Therefore, ADA recommends a change of toothbrush every 3 months.

Contaminated toothbrushes can lead to reinfection of the oral cavity via the injuries caused to gingiva during brushing which is why disinfection of toothbrushes regularly is crucial. Various methods of toothbrush sanitization have been tested such as UV light, microwave, immersion in chemical and herbal solutions, etc. Although it is expensive, the UV light toothbrush holder has the maximum efficacy among all the methods. Among the chemical agents, chlorhexidine gluconate (0.2%) was found to significantly reduce the bacterial load and is also cost-effective.

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