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The effect of *Salvadora persica* herbal toothbrush on the surface roughness of enamel

Naser Sargolzaei[1], Hediyeh Toutouni[2], Shayan Yousefi[3], Amirreza Taghavi[3], Setayesh Sargolzaei[3], Zeinab Ghasemi[1]*

Abstract

Objective: This in vitro study investigated the abrasive properties of the *Salvadora persica (S. persica)* herbal toothbrush in comparison to a soft toothbrush on enamel.

Methods: Sixty bovine central incisors were obtained and randomly divided into two groups (n=30) according to the type of toothbrush used. Group 1 was brushed with an *S. persica* toothbrush, while Group 2 was brushed with an Oral-B soft toothbrush. The teeth were mounted in an artificial mouth device and brushed twice a day for 2 minutes per session. This brushing regimen was maintained for seven consecutive days, with the specimens stored in distilled water between brushing cycles. The enamel surface roughness was measured before and after the brushing process by a stylus profilometer, and the average surface roughness value (Ra) was recorded. The data were analyzed using independent samples and paired samples t-tests ($\alpha = 0.05$).

Results*:* The enamel surface roughness decreased significantly in both groups after brushing ($P < 0.001$). There were no significant differences in surface roughness between the two groups, either at baseline (*S. Persica*: 0.33 ± 0.16 µm; Oral-B: 0.36 ± 0.12 µm; P=0.493) or at the end of the experiment (*S. persica*: 0.28 ± 0.11 µm; Oral-B: 0.32 ± 0.08 µm; P=0.216).

Conclusions: Brushing with either the *S. persica* or Oral-B soft toothbrush reduced enamel surface roughness. The *S. persica* toothbrush produced a mean surface roughness value comparable to that of the regular soft toothbrush, and thus it may be considered as a suitable alternative to conventional toothbrushes.

Keywords*:* Dental abrasion, Dental enamel, Dental plaque, *Salvadora persica*, Surface properties, Toothbrush

Introduction

Maintaining oral health is primarily achieved through both chemical and mechanical methods, with toothbrushes and toothpaste being the most common ways to clean teeth (1). However, excessive or improper use of toothbrushes and toothpaste can cause damage to both soft and hard tissues.

Dental abrasion is the most frequently observed injury to oral hard tissues (2), manifested as wear of the tooth surface, particularly near the gum line. Factors such as poorly designed bristles, frequent or prolonged brushing, abrasive toothpaste, and improper oral hygiene techniques can contribute to dental abrasion over time (3). Dental abrasion creates microscopic and macroscopic irregularities on tooth surfaces. This increase in surface roughness makes the surface less smooth and susceptible to cervical decay, root caries, and dental sensitivity (4).

Despite the widespread use of conventional toothbrushes and toothpaste, there is a growing preference for herbal alternatives in many regions of the world. This practice is partly derived from the cultural heritage in countries such as Saudi Arabia, India, and some parts of Iran (1). Chewing sticks from plants, including mango, Babul, and *Salvadora persica* (*S. persica*), have long been used across Asia, Africa, South America, and the Middle East (5, 6). Among these, *S. persica* (commonly known as the Miswak) is the most popular due to its easy accessibility, low cost, and ease of use (7). These sticks have been reported to provide several benefits, including mechanical plaque removal,

[1] Department of Periodontics, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran.
[2] Department of Community Oral Health, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran.
[3] Student Research Comittee, Mashhad University of Medical Sciences, Mashhad, Iran.

*Corresponding Author: Zeinab Ghasemi

Email: GhasemiZ4011@mums.ac.ir

reduction of gingival inflammation, assistance in calculus removal, and promotion of remineralization (8, 9). Additionally, *S. persica* contains constituents such as vitamin C, fluoride, chloride, and flavonoids, some of which exhibit antibacterial properties (10).

Previous studies demonstrated that the regular use of the miswak reduces plaque, gingival inflammation, and bleeding (11). Additionally, *S. persica* helps maintain the pH of the oral environment within normal limits following an acid attack (8, 12). The incidence of dental caries in individuals using these herbal toothbrushes is remarkably low (13, 14). Furthermore, the essential oils extracted from *S. persica* contain a mixture of monoterpene hydrocarbons and oxygenated monoterpenes, which possess antifungal properties against Candida species (15). A meta-analysis demonstrated that extracts from *S. persica* significantly reduce plaque and the count of cariogenic bacteria (16). Furthermore, this plant contains fluoride, phosphate, and calcium, which may help remineralize early carious lesions (17). Using *S. persica* also stimulates saliva production and increases the buffering capacity of the oral environment (12).

Despite the numerous benefits of the *S. persica* herbal toothbrush, some side effects, such as gingival recession, have been reported (18, 19). Bawazeer et al. (20) evaluated the abrasive effects of *S. persica* aqueous extracts on the acid-eroded enamel surface. Others evaluated changes in tooth hardness following the application of Miswak (21). However, there is little evidence on the impact of the *S.persica* toothbrush on enamel surface roughness. The present study evaluated changes in enamel surface roughness after brushing with an *S. persica* toothbrush as compared to a soft-bristled Oral-B toothbrush.

Materials and Methods

The protocol for this in vitro study was approved by the ethics committee of Mashhad University of Medical Sciences (IR.MUMS.DENTISTRY.REC.1401.032).

Sample Preparation

A total of 60 extracted central incisors from young bovines (18–30 months old) were obtained from a slaughterhouse. The teeth were carefully examined under a stereomicroscope, and those with caries, cervical lesions, fractures, cracks, or developmental defects were excluded. The selected teeth were stored in distilled water at room temperature until use.

The crowns were separated from roots with a trimmer and embedded in self-cure acrylic resin (Acropars, Marlic Co., Tehran, Iran), so that the tooth surface lay parallel to the horizon. The enamel surface was then polished with 800–1200-grit silicon-carbide papers (Matador; Starcke GmbH & Co. KG, Melle, Germany) under continuous water irrigation.

Study Groups and Brushing Protocol

The specimens were randomly assigned to two groups of 30, based on the toothbrush applied:

- Group 1: *S. persica* toothbrush (Chewak, Iran)
- Group 2: Oral-B soft toothbrush (Procter & Gamble, Cincinnati, OH, USA)

The toothbrushes were embedded in self-cure acrylic resin (Figure 1). The teeth were mounted in self-cure acrylic resin and placed in an artificial mouth device (Figure 2). The brushes were then inserted into a toothbrushing simulator (Delta Electronics, Taipei, Taiwan) to standardize the brushing process (Figure 2).

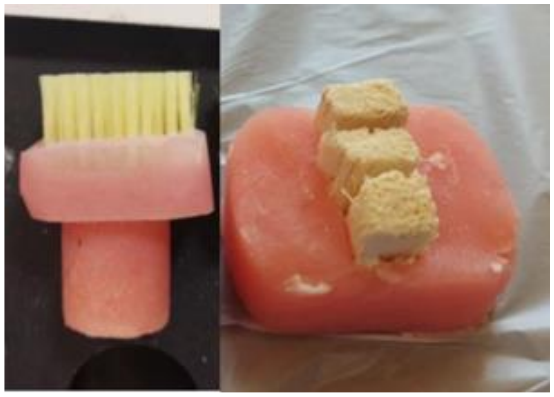

Figure1. A: Mounted Oral B toothbrush, B: Mounted Salvadora Persica toothbrush

Figure2. The artificial mouth device and the toothbrushing simulator used in this study

A vertical load of 200 g was applied, with stroke frequency and brushing duration carefully controlled.

Brushing was performed twice daily for two minutes each using a back-and-forth horizontal motion (horizontal Scrub technique). The brushing process was continued for one week, totaling 10,000 strokes per tooth. Each toothbrush was replaced after brushing five teeth. Between sessions, specimens were stored in distilled water at room temperature.

Surface Roughness Assessment

Enamel surface roughness (Ra, µm) was measured at baseline and after brushing using a contact stylus profilometer (TIME TR200; TIME Group, Beijing, China), calibrated according to the manufacturer's instructions. Ra, defined as the arithmetic average of the absolute vertical deviations of the surface profile from the mean line, was recorded for each specimen.

Statistical Analysis

Statistical analyses were performed using SPSS version 23 (IBM Corp, Armonk, NY, USA). The normality of the data distribution was confirmed using the Shapiro–Wilk test ($P< 0.05$). Data were analyzed using independent-samples and paired-samples t-tests, with a significance level set at $P < 0.05$.

Results

Table 1 presents the surface roughness of both groups before and after the intervention. The results of the paired-samples t-test indicated a significant reduction in surface roughness after brushing in both the Oral-B and *S. persica* toothbrush groups (P=0.001; Table 1).

Between-group comparisons showed no significant difference in enamel surface roughness either at baseline (P = 0.493) or after the brushing process (P = 0.216; Table 1).

Discussion

This in vitro study evaluated changes in enamel surface roughness after standardized brushing with a *S. persica* toothbrush compared with a soft-bristled conventional brush. Since brushing technique and applied force can affect dental abrasion (22), the study was conducted under controlled laboratory conditions to minimize variability. The toothbrushes were mounted uniformly in acrylic resin and placed in a toothbrushing simulator, where brushing frequency and force were standardized for both groups. The brushing force was fixed at 200 g, which is close to the average force applied by the general population and has been employed in previous studies (2, 23, 24). The recommended time for effective plaque removal is two minutes twice a day (25), and thus, this duration was used in this study. The brushing procedure was conducted over one week.

The profilometry technique was used in this study to assess enamel surface roughness. This technique is a reliable and widely accepted method for assessing roughness in laboratory studies. Its main advantages are precision, reproducibility, and providing quantitative values, making it useful for detecting small changes in surface topography over time. However, this technique has some limitations, as it provides only two-dimensional line profiles rather than full three-dimensional surface mapping, which may limit the complete characterization of enamel morphology.

The bristle diameter of toothbrushes typically ranges from 0.2 mm for soft bristles to 0.4 mm for hard bristles (26). It is usually suggested to use toothbrushes with smaller, round heads and soft or medium nylon bristles, as they cause less trauma to oral tissues (27). Although hard-bristled toothbrushes can remove more bacterial plaque, they are also associated with greater gingival recession (28). Accordingly, a soft-bristled Oral-B toothbrush was used in the control group. Commercially available *S. persica* toothbrushes (Chewak, Iran) were selected to ensure standardized bristle geometry and compatibility with the toothbrushing simulator.

At baseline, the surface roughness of the *S. persica* toothbrush was 0.33 ± 0.16 µm, and that of the Oral-B toothbrush was 0.36 ± 0.12 µm. The statistical analysis revealed no significant differences in enamel roughness between the two groups. After one week of simulated

Table 1. Mean ± standard deviation (SD) of enamel roughness (µm)

Groups	Baseline Mean ± SD	Post-intervention Mean ± SD	P value
Group 1 (*Salvadora persica* toothbrush)	0.33 ± 0.16	0.28 ± 0.11	0.001
Group 2 (Oral-B toothbrush)	0.36 ± 0.12	0.32 ± 0.08	0.001
P value	0.493	0.216	

brushing, surface roughness decreased significantly in both groups. Post-intervention values were 0.28 ± 0.11 µm for *S. persica* and 0.32 ± 0.08 µm for Oral-B toothbrushes, with no significant difference between groups. These results indicate that both toothbrushes produced a significant reduction in enamel surface roughness.

The significant reduction in surface roughness after brushing is likely due to the mechanical polishing effect of toothbrushes. During brushing, the toothbrush can gradually wear down the microscopic peaks and irregularities on the surface. This leveling of surface peaks leads to a reduction in surface roughness. This effect often occurs when the abrasive action removes protrusions without causing deeper wear. Additionally, factors such as brushing duration, applied pressure, and the type of toothbrush used can influence the polishing and smoothing effects.

In the present study, the enamel roughness of samples brushed with *S. persica* was not significantly different from that of the samples brushed with the Oral-B soft toothbrush. A potential concern with the use of *S. persica* toothbrushes is the risk of gingival recession and dental abrasion (18-20). However, the findings of this study suggest that such adverse effects are more likely related to improper or excessive use rather than the *S. persica* sticks themselves (18, 19). Therefore, this herbal toothbrush may serve as a potential alternative to conventional toothbrushes in clinical practice.

Almas et al. (29) compared the abrasive effects of *S. persica* filaments with those of Butler and Aquafresh toothbrushes. They found that *S. persica* and Butler toothbrushes produced comparable levels of enamel abrasion, both significantly lower than the abrasion caused by the Aquafresh toothbrush. These findings are consistent with the results of the present study. However, their study involved manual brushing for 60 seconds on extracted human central incisors, and enamel surface roughness was evaluated using microscopy. In contrast to the outcomes of this study, Abdellatif et al. (30) evaluated the effectiveness of miswak (*S. persica*) and a conventional toothbrush in the reduction of dental plaque and gingival inflammation in 60 participants. After two weeks, the patients in the miswak group indicated significantly higher plaque and gingival scores compared to the toothbrushing group. The author attributed this unfavorable finding to the incorrect use of miswak and recommended proper training of patients for miswak use.

The use of toothpaste is an important factor influencing dental abrasion when conventional toothbrushes are used. One study reported that soft toothbrushes combined with toothpaste caused greater abrasion than hard toothbrushes used without toothpaste (31). As both the soft-bristled Oral-B and the *S. persica* toothbrush produced significant reductions in enamel roughness in the present study, it may be inferred that the greater abrasion often attributed to the toothbrushing process could be related to the use of toothpaste rather than the toothbrush alone.

This study was conducted in the in vitro setting, and this should be considered as a limitation. In clinical conditions, the degree of dental abrasion can vary across different regions of the mouth and is influenced by individual differences in tooth structure. Furthermore, variations in toothpaste use, brushing force, and brushing duration among individuals may affect the extent of dental abrasion. Future studies should therefore investigate the combined effects of different toothbrushes and toothpaste, and compare these findings with those of the *S. persica* toothbrush.

Conclusions

Within the limitations of the present study, it can be concluded that

- Brushing with *S. persica* and Oral-B toothbrushes caused a significant reduction in enamel surface roughness.
- The surface roughness of samples brushed with the *S. persica* toothbrush was comparable to that of the samples brushed with the Oral-B soft toothbrush. Therefore, this herbal toothbrush may serve as a potential alternative to conventional toothbrushes in clinical practice.

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Conflict of interest

The authors declare that they have no conflict of interest.

Author contributions

N.S., H.T., and Z.G. contributed substantially to the study's concept and design, supervised the study, and proofread the manuscript. S.Y., A.T., and S.S. conducted the study, collected and analyzed the data, and prepared the first draft of the manuscript. All authors read and approved the final manuscript.

Ethical approval

The protocol for this in vitro study was approved by the ethics committee of Mashhad University of Medical Sciences (IR.MUMS.DENTISTRY.REC.1401.032).

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