

The Two-Dimensional Effects of *Salvadora persica* Mechanical Brushing on the Surface of Polymethyl Methacrylate Denture Base Material

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Abstract

Miswak sticks commonly derived from *Salvadora persica*, has been extensively used as oral hygiene aids since ancient times. The antimicrobial effect of miswak is proven to reduce denture induced stomatitis in denture wearers. Dentures need to be cleaned to maintain its aesthetics and prevent candida growth. The selection of denture cleaning aids and methods are crucial as not to compromise the physical properties of the denture base, namely poly methyl methacrylate (PMMA). A study was conducted to assess the two-dimensional (2D) mechanical brushing effects towards the PMMA denture base materials. Nine PMMA samples sized 20x20x5mm were prepared and sent for scanning electron microscopy tests (SEM) prior to any tests as baseline record. All samples were mechanically brushed using toothbrushing simulator machine and the brush materials are miswak, soft toothbrush and soft toothbrush with toothpaste. The samples were brushed for 17800 and 53400 strokes to simulate one and three years of mechanical brushing before the second SEM. SEM micrographs were examined and interpreted descriptively. After mechanical brushing, the sample surfaces demonstrated multiple layers of 2D grooves on the brushed areas. Soft toothbrush with toothpaste showed the most severe effect and the least effect was observed if brushed with miswak. This study concludes that miswak showed the least effect with minimal grooves on the surface of PMMA plates after three years of mechanical brushing.

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Introduction

Maintaining good denture hygiene is crucial for denture wearers in order to prevent malodour, improve the aesthetics, prevent candida growth and also to maintain the oral health so that the longevity of the prostheses can be increased. Denture wearers need to clean their dentures at least once a day and soak the denture in water overnight when they go to bed. The dentures can be mechanically cleaned by using soft toothbrush or sponge and also dentrifice and water to remove stains and dental plaque.

Denture base is the main part of the denture that supports artificial teeth. The most

commonly used material for denture base is polymethyl methacrylate (PMMA). This material has been proven to have good biocompatibility and dimensional stability with less tissue irritation and toxicity.¹ The adhesion of artificial teeth to PMMA denture base is excellent and presented with good aesthetics as it can mimic the colour of the gingiva and colour stable. PMMA is also insoluble in body fluids making it durable to be used,² even though the polymer is considered relatively soft when compared to cobalt-chromium denture base. The relatively soft physical properties may cause the acrylic denture base to wear, which might be caused by abrasive food, abrasive dentrifice cleansers or mechanical brushing. Therefore, it is very crucial for the patient to choose the cleaning aids and methods wisely, as inappropriate methods might compromise with the surface texture of the denture thus will reduce the longevity of the denture.

Tooth cleaning stick or miswak in Arabic derived from several plant species. Miswak harvested from *Salvadora persica* is among the

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most extensively used for oral hygiene purposes. Miswak can be obtained from the twigs, roots and stems of the species.³ The use of miswak has been acknowledged and emphasised in Islam for oral hygiene care and has been used as chewing sticks since before the invention of toothbrush.

Salvadora persica plant and its extracts is proven to be beneficial to oral tissues and helps to maintain superior oral hygiene.⁴ In vitro studies have shown that miswak has antibacterial effects towards microbes present in the mouth such as *Candida albicans* due to its high sulphate content.⁵ Miswak also presented with strong antimicrobial effects on *Streptococcus sp.* and *Staphylococcus aureus* which will significantly lower the number of cariogenic bacteria in the saliva.^{6,7}

Despite the proven advantages and uses of miswak towards oral health, studies are yet to advocates the use of miswak to clean the denture bases as well as assessing the mechanical brushing effect of miswak on polymethyl methacrylate (PMMA) denture base material. Therefore, this study was conducted to assess the two-dimensional mechanical brushing effects of miswak, toothbrush and toothbrush with toothpaste on PMMA denture base material.

Materials and methods

Preparation of PMMA samples

Nine (9) rectangular polymethyl methacrylate (PMMA) blocks sized 20mm width x 20mm length x 15mm thick were fabricated by using waxes of the same thickness placed on each stone cast. The waxes later were embedded in dental stone using flasks based on the conventional flasking procedures. Dewaxing procedure was carried out one hour after flasking by placing the flasks in boiling water for 10 minutes. The residual wax was removed with boiling water. PMMA acrylic resin material was mixed with 3:1 polymer to monomer ratio according to manufacturer's instructions. Once the mixed acrylic has reached the plastic dough stage, it was homogenized and packed into the flasks with 1250 kgf/cm² final packing pressure. Strain clamps were placed on the flasks and underwent the curing cycle in waterbath for 9hours at 74°C, according to the manufacturer's instructions. After polymerization, the samples were bench cooled at room temperature before they were deflasked. The resin plates were

trimmed and polished according to standard denture making procedure. All samples were sent for initial scanning electron microscopy (SEM) images with magnification of X150 to X300.

Brushing procedure

Miswak (*Salvadora persica*) sticks are bought in bundle and of same brand to ensure its composition similarities. The sticks were cut into 3cm long and the bark was peeled and frayed at the end of the sticks converting the stick into a brush. The miswak sticks was then attached to the tooth brushing simulator machine.

Brushing simulator was used to brush all PMMA samples to obtain the mechanical brushing effect. The resin plate was brushed using toothbrushing simulator machine using miswak, soft bristle toothbrush and soft bristle toothbrush with toothpaste. The brushing was under constant frequency for 17,800 strokes to the PMMA samples surface which was equivalent to 1 year of normal manual brushing and then another 35,600 strokes were added to get a total of 53,400 strokes which correspond to 3 years of brushing strokes.⁸ Miswak sticks were changed for every 17,800 strokes. The tests were repeated three times for each brushing method.

Tooth brushing simulator machine

A toothbrushing simulator machine used was developed in the Faculty of Dentistry, Universiti Sains Islam Malaysia. The plane brush head on the machine was replaced with miswak stick. The force applied on the sample was set to 10g with frequency 15 strokes/minutes on occlusal and buccal surface. The device made two strokes of horizontal movements per seconds.

Data collection: Scanning Electron Microscopy (SEM) reading

All PMMA sample plates were tested by using scanning electron microscopy (SEM) after being brushed for 17,800 strokes and 53,400 strokes. The micrographs were taken at X150 to X300 magnification and the images were interpreted descriptively.



Figure 1. Initial micrograph SEM images of samples prior to mechanical brushing.

Results

The SEM images taken prior to any mechanical brushing conducted showed no obvious grooves effect presented and with slight polishing paste particles on the samples (Figure 1). These images will be used as control. After one year of mechanical brushing (17800 strokes), light grooves presented on all samples brushed using miswak sticks (Figure 2a), soft toothbrush (Figure 2b) and soft toothbrush with toothpaste (Figure 2c). The groove effects were almost identical for all samples (Figure 2).

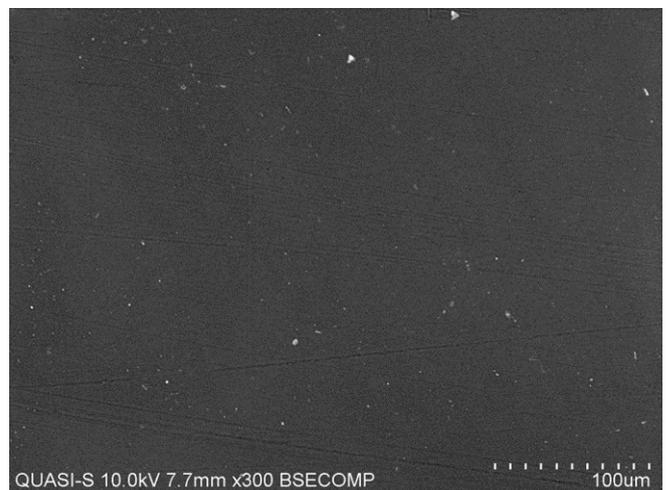


Figure 2a. SEM images micrographs of PMMA samples after 17800 strokes of mechanical brushing using miswak sticks.

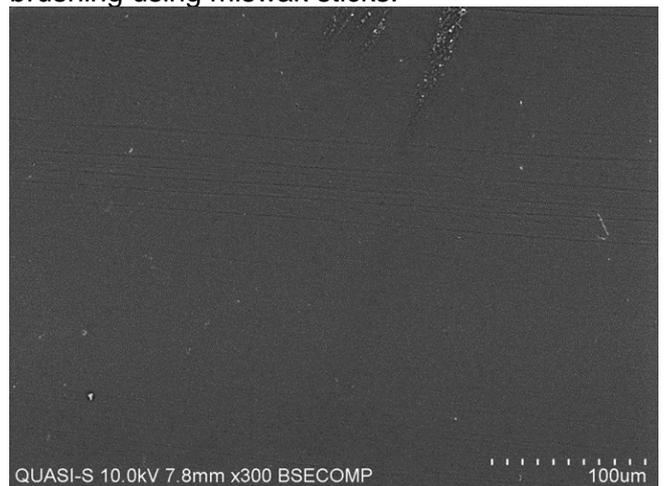


Figure 2b. SEM images micrographs of PMMA samples after 17800 strokes of mechanical brushing using soft bristle toothbrush.

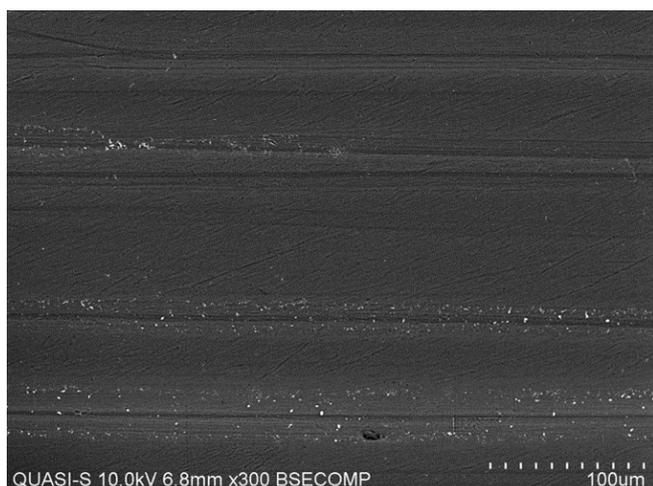


Figure 2c. SEM images micrographs of PMMA samples after 17800 strokes of mechanical brushing using soft bristle toothbrush with toothpaste.

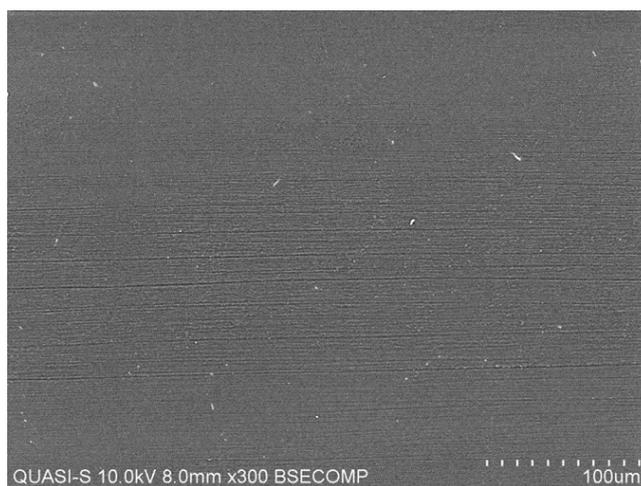


Figure 3b. SEM images micrograph of PMMA sample after 53400 strokes of mechanical brushing using soft bristle toothbrush.

However, after 53400 strokes of mechanical brushing, samples brushed with miswak presented with prominent groove effects and scattered with some distance between the grooves (Figure 3a). Mechanical brushing using soft bristle toothbrush resulted in prominent and consistent grooves which are in line and near to each other (Figure 3b). The use of toothbrush and toothpaste for mechanical brushing resulted in prominent grooves with debris produced from the toothpaste were found on the PMMA plates (Figure 3c).

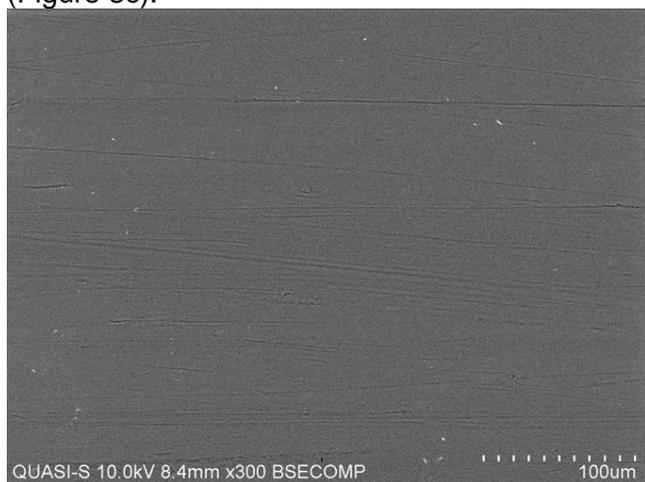


Figure 3a. SEM images micrograph of PMMA sample after 53400 strokes of mechanical brushing using miswak sticks.

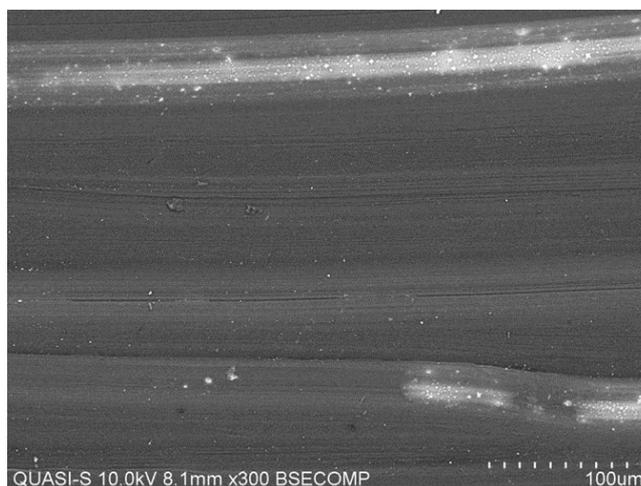


Figure 3c. SEM images micrograph of PMMA sample after 53400 strokes of mechanical brushing using soft bristle toothbrush and toothpaste.

Discussion

Oral health is one of the important aspects that contributes to the general wellbeing of a person. The use of toothbrushes have been advocated as the main mechanical cleaning aids to remove plaque and bacteria from the oral cavity in order to maintain the oral hygiene. Several toothbrushing techniques and several types of toothbrushes have been introduced with some are superior than the others, for instance, the curved bristle toothbrushes is more effective in removing plaque compared to the conventional brushes.⁹ The maintenance and care of the toothbrushes are also important to ensure that

the brushes are in excellent condition for the mechanical brushing. Toothbrush is known as the medium of transfer of microbes, their retention and also growth, for it has been shown to become highly contaminated after usage with coliform bacilli and *Pseudomonas aeruginosa* as the domination microbes.¹⁰

Another method for mechanical brushing is via the use of miswak. Miswak can be used as chewing sticks as well as for mechanical brushing and also can be added in mouthrinses and toothpastes. Epidemiological studies have shown that the use of miswak as chewing sticks can result in lower caries prevalence compared to toothbrush users due to its ability to effectively reduce dental caries and dental plaque.^{11,12} The ability of miswak in increasing the salivary flow by simulating the parotid gland secretion will also help to prevent dental caries through saliva flushing effect and improving the pH of the saliva.¹³ When compared between miswak and conventional toothbrushes, the mechanical cleaning action of miswak is proven to be better to reduce the plaque scores compared to toothbrushes.¹⁴ Miswak is considered to be better as it is more affordable and readily available to be used by vast majority of people in certain countries as an oral hygiene device.¹⁵

A study has been conducted in Faculty of Dentistry USIM to study the effect of miswak in treating denture stomatitis.¹⁶ In this study, patients were asked to use miswak for mechanical cleaning of the affected mucosa in order to improve their condition. This study showed positive response where the treatment has significantly improve denture stomatitis in the patients, and the effects were mainly due to the above mentioned excellent properties of miswak.

The composition of miswak includes silica, tannic acid, resins, sodium bicarbonate, alkaloids (salvadorine), volatile oils (simgrins), calcium, sulfur, vitamin C, trimethylamine, salicylic acids, chlorides, benzylisothiocyanate (BIT), fluorides, sterols, saponins and flavonoids.¹⁷ Vitamin C and sulphur in miswak will promote tissue healing to the mucosa.¹⁸ Salvadorine and trimethylamine were proven to exhibit antibacterial properties towards cariogenic bacteria such as *Streptococcus mutans*.

Silica in miswak is believed to be the reason of the abrasive properties of miswak.⁶ The abrasive effect of miswak can prevent plaque accumulation and promotes tissue

healing as well as effective in removing stains from tooth surfaces.⁶ However, the use of abrasive agents in denture cleaning aids without proper care, can also cause surface abrasion of the PMMA denture base materials.

In this study, the abrasion on the denture surface from miswak mechanical brushing are in form of grooves formed by the abrasive agent in the cleaning aids. It was shown that after one year of mechanical brushing, the abrasive effects was the worst in soft toothbrush with toothpaste but similar effect between soft toothbrush and miswak. However, after three years of mechanical brushing, miswak presented with the least grooves on PMMA denture base material compared to soft toothbrush and soft toothbrush with toothpaste. Mechanical brushing using soft toothbrush resulted identical layers of abrasive lines close to each other, compared to miswak which was more scattered and the use of toothpaste which resulted in severe crazing of the PMMA surface.

The groove defects produced by mechanical brushing can lead to formation of crazing on the polished PMMA surfaces thus might compromised the denture hygiene as it can be plaque retentive and correlated with the early stage of biofilm formation by *Strep.oralis*.¹⁹ The grooves can also increase the biofilm retention¹⁸ and thus making the denture prone for colonization of candida. Candida colonization on the denture bases will result in denture stomatitis.

The crazing / abrasion of the PMMA denture base can also affect the denture strength and will compromise the its longevity. The impact resistance of acrylic resins was shown to be significantly reduced by the presence of very small surface defects.²⁰ The surface defects can be in a form of porosity, contamination in the acrylic resin as well as surface abrasion. The abrasion on acrylic base material is influenced by the denture base's chemical composition, crystalline structure, friability, solubility and concentration of the material, its physical property (hardness) as well as the size and shape of the particles and its compatibility with other ingredients in the dentifrice.²¹ The use of toothbrush on the denture base will also results in surface abrasion of the acrylic resin. The degree of abrasion from toothbrush is influenced by the bristle stiffness, toothbrushing technique and frequency, the hardness of the denture base material and the use of dentifrices.²²

Conclusions

It can be concluded that miswak has the potential to be used as a denture cleaning aid on PMMA denture base material as it presented with the least abrasive effect from this two-dimensional study. Taking into account that replacement of dentures need to be made within three to five years, with proper care and guidelines, the use of miswak can be advocated for denture wearers as part of their denture hygiene care regime. However, detailed assessments need to be conducted to further assess the effect of mechanical brushing on the properties of PMMA denture base material.

Declaration of Interest

None declared.

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