

The Effect of the Surface Roughness of Porcelain on the Adhesion of Oral *Streptococcus mutans*

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Abstract

Aim: Dental plaque has a harmful influence on periodontal tissue. When a porcelain restoration is fabricated and refinishing of the glazed surface is inevitable, the increase in surface roughness facilitates the adhesion of plaque and its components. The aim of this *in vitro* study was to evaluate the effect of surface roughness of glazed or polished porcelain on the adhesion of oral *Streptococcus mutans*.

Methods and Materials: A total of 80 metal-ceramic specimens were prepared in the form of disks from two porcelain materials and divided into four groups according to the method of surface finishing. Surface roughness values (Ra- μm) for all specimens were recorded using a profilometer. *S. mutans* bacteria were isolated from saliva and all specimens were inoculated in test tubes containing a bacterial suspension allowing adhesion of the microorganisms to the specimens to occur. After incubation for 24 hours at 37°C, the specimens were transferred to a sterile saline solution and an inoculum of 0.1 ml from each selected dilution was spread on the selective medium, mitis salivarius bacitracin agar (MSB). Bacterial counts, expressed in colony forming unit (CFU) taking into consideration the dilution factor, were recorded.

Results: There was significant correlation ($p < 0.05$) between surface roughness values (Ra- μm) and the amount of bacterial adhesion ($\text{CFU} \times 10^3$). The glazed surface was the smoothest and exhibited the least amount of bacterial adhesion.



Conclusions: A positive correlation between surface roughness and the amount of *S. mutans* adhesion was observed. The glazed porcelain surface was considered more biocompatible than other methods of porcelain surface finishing.

Clinical Significance: Chairside adjustments of the cervical contour or occlusal surface of porcelain restorations are sometimes necessary before or after cementation. Ideally, an uncemented restoration should be returned to the laboratory for reglazing after all adjustments have been completed.

It is important to evaluate various polishing procedures used for these adjusted surfaces

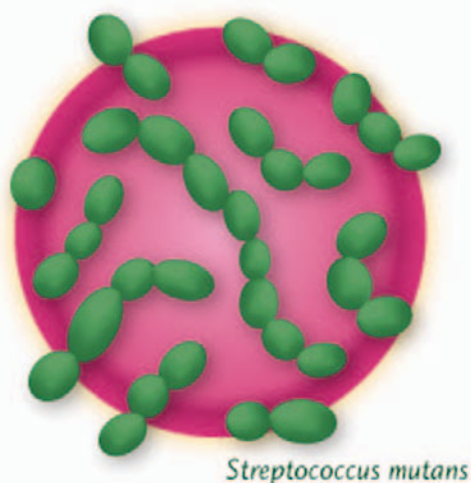
to achieve a finished surface that as closely as possible approximates the quality of glazed porcelain.

Keywords: Porcelain, glazing, polishing, *Streptococcus mutans*, bacterial adhesion.

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Introduction

Metal-ceramic crowns and bridges are commonly used in fixed prosthodontics because of their excellent biocompatibility and superior esthetic qualities.¹ A risk of caries incidence should be negligible for a full-coverage restoration, but much attention has been given to the health of the adjacent gingival tissues.² Special attention needs to be paid to the assessment of ceramic materials that come in contact with periodontal tissues such as the pontics of fixed prostheses coming in contact with gingival tissue.³ The surface smoothness of the ceramic materials is a key factor for long-standing dental restorations because it directly influences the cleanability and the retention of microbes.⁴ Surface roughness is an important factor influencing the amount of plaque accumulation² because bacterial cell attachment is expected to increase with an increase of the porcelain surface roughness.⁵



The purpose of glazing is to seal the open pores in the surface of fired porcelain. Small air voids in the porcelain that are exposed at the surface allow the ingress of bacteria and oral fluids and act as potential sites for the build-up of plaque.⁶ Chairside adjustments of cervical contours or occlusal surfaces are sometimes necessary that alter the glazed porcelain surface.⁷ Ideally, porcelain restorations should maintain their surface glaze so, whenever possible, altered restorations should be reglazed in the dental laboratory before final cementation without further chairside corrections of the restoration surface.⁸ A break in the glazed surface of a cemented restoration should not be ignored as well. Depending on the location, the rough surface needing adjustment can cause accelerated abrasive wear of the opposing dentition, or facilitate a greater rate of plaque accumulation.⁹ Reglazing is not possible when the adjustment was made after cementation of the restoration; therefore, polishing of the restoration is the best alternative.¹⁰

Poor polishing generates rougher surfaces, inducing more plaque accumulation, resulting in periodontal tissue inflammation.² The ultimate goal of polishing is the attainment of a well-polished surface as a substitute for glazed porcelain.¹¹ So, it is important to compare and evaluate the polishing procedures of adjusting rough porcelain surfaces clinically in terms of ease of use and practicality.⁷

Streptococci constitute a major population in the oral cavity, with several different species colonizing the various ecological niches of the mouth.¹² Of them, *S. mutans* and *S. sobrinus* have been the most frequently isolated species from the oral cavity.¹³ *S. mutans* are considered to be cariogenic because they have the capacity to synthesize adhesive glucans that enable the bacteria to adhere to even a smooth surface such as enamel or a restoration.¹⁴ Although streptococci may be associated with a healthy periodontium, their presence leads to coaggregation by periodontopathic bacteria, i.e., *Porphyromonas gingivalis* and *Actinobacillus actinomycetemcomitans* (Aa).¹⁵

The aim of the present *in vitro* study was to evaluate the effect of surface roughness of glazed or polished porcelain on the adhesion of oral *Streptococcus mutans*.

Methods and Materials

Metal-ceramic specimens used in this study were fabricated in the forms of disks (2.5 mm thick and 12 mm in diameter). Sheets of 0.5 mm thick modeling base plate wax were used to prepare 80 wax patterns to cast the disks. VITA VMK 95 (Vita Zahnfabrik, Bad Säckingen, Baden-Württemberg, Germany) and MAJOR (MajorDent, Moncalieri, Torino, Italy) were two types of porcelain materials used for the fabrication of the porcelain component of the disk and fired in a porcelain furnace according to the manufacturer's recommended firing chart.

All specimens were then abraded before surface finishing with diamond burs to simulate a clinical adjustment. Every 40 metal-ceramic specimens made from the same type of porcelain were divided randomly into four groups according to the method of surface finishing as follows:

- **Group A:** polished with silicon polishing burs using a low-speed handpiece for 10 seconds at 35,000 rpm.
- **Group B:** polished with 240-grit sandpaper attached to a mandrel bur in a form of disks using a low-speed handpiece for 10 seconds at 35,000 rpm.
- **Group C:** sandblasted using aluminum oxide (particle size 50 μm) for 20 seconds at a pressure of 3 bars and mounted at a distance of 50 mm from the sandblaster nozzle tip with a special holder fixed inside the machine.¹⁶
- **Group D:** glazed by adding glaze material and firing the specimens in the porcelain furnace.

The average value of surface roughness (R_a - μm) of all specimens was measured using a profilometer. The profilometer measured each specimen in three areas of the disk with a maximum travel distance of 11 mm. The average value was recorded.

The *S. mutans* was obtained by collecting an unstimulated whole saliva (UWS) sample from a young volunteer using a spitting method. The saliva sample was dispersed using a vortex mixer for 2 minutes then 0.1 ml was spread in duplicate on the MSB agar media. The media plates were then incubated anaerobically using a gas pack for 48 hours at 37°C, then aerobically for 24 hours at room temperature.

The metal surfaces of all disk specimens were covered by tape to prevent bacterial adhesion on these surfaces, then attached to orthodontic wire to hold and stabilize each specimen in the broth to facilitate disk immersion and removal. Each specimen was inserted in 5 ml of brain heart infusion (BHI) broth containing 5% sucrose and was completely covered by the broth as shown in Figure 1. The specimens were then sterilized in an autoclave for 20 minutes at 121°C.

The test tubes were then inoculated with 2% bacterial isolates removed from the MSB agar. Immediately after bacterial inoculation, the test tubes were incubated aerobically for 24 hours at 37°C. Upon removal of them from the BHI broth, the tape covering the metal surface was removed from the specimens. Then the specimens were transferred to sterile saline solution and vortexed for 1 minute using a vortex mixer.

Serial dilutions were performed as depicted in Figure 2 by transferring 0.1 ml to 0.9 ml of sterile saline solution. The inoculums were chosen to be withdrawn from the third dilution (10^{-3}) because a readable count of bacteria can be seen on the agar surface at this dilution as determined by a pilot study.

Aliquots of 0.1 ml from the selected dilution were plated onto MSB agar plates using a sterile microbiological spreader and incubated anaerobically at 37°C for 48 hours, followed by 24 hours of aerobic incubation at the same temperature. The number of colonies were



Figure 1. The disk specimens in BHI broth for the bacterial adhesion test.

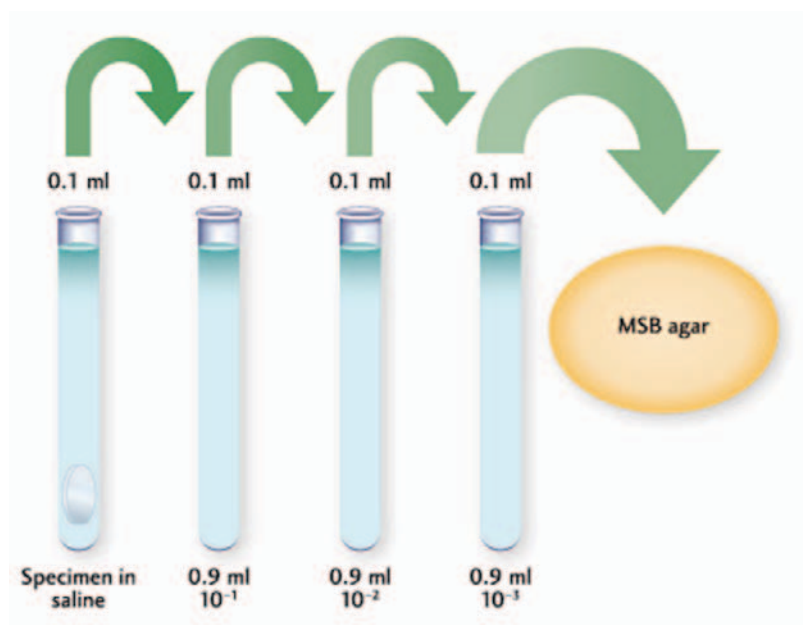


Figure 2. Serial dilutions in saline.

counted taking into consideration the dilution factor (Number of colonies \times Inverse of the dilution) and expressed as colony forming units of *S. mutans* (CFU $\times 10^3$).

MSB agar is the selective medium for the cultivation of *Streptococcus mutans*. The selective property is determined by the addition of optimum levels of sucrose and bacitracin to the mitis salivarius agar composition for effective inhibition of bacteria other than *S. mutans* since it is relatively resistant to high concentration of both sucrose and bacitracin.¹⁷

Results

The results of the profilometric study are illustrated in Figure 3. The surface obtained by glazing was the smoothest, followed by the surface polished by 240-grit sandpaper, then the surface polished with a silicon polishing bur (Quayle Dental, Worthing, West Sussex, England). The surfaces of specimens that were sandblasted were the roughest.

The quantity of bacteria that adhered to the porcelain specimens is shown in Figure 4. The glazed surface exhibited the least amount of bacterial adhesion compared to other methods of surface treatment.

The findings of the study showed there were no

significant differences between the two types of porcelain used in relation to both surface roughness and bacterial adhesion for all methods of surface finishing. *S. mutans* colonies grew on the MSB agar plates as highly adherent convex, raised, light-blue colonies with a frosted-glass appearance and either a rough or smooth surface. Gram staining was used to confirm the diagnosis of *S. mutans*. Gram positive spherical or ovoid cells arranged in short- or medium-length chains are indicative of the isolation of streptococci cells. In addition, biochemical tests were used to verify the identification of *S. mutans*. All colonies of *S. mutans* were catalase negative and had the ability to ferment mannitol.

The statistical analyses revealed a positive correlation between the surface roughness value and the amount of *S. mutans* bacteria that adhered to each porcelain surface that was finished using one of the four types of surface finishing methods. The relationship between the Ra value and the bacterial count for all the surface finishing methods was significant (Pearson correlation $r=0.813$, $p=0.003$; $p<0.05$).

Discussion

The results of the study reflect a genuine relationship between the surface roughness of porcelain and bacterial adhesion. This can be explained by the fact that a rough surface has

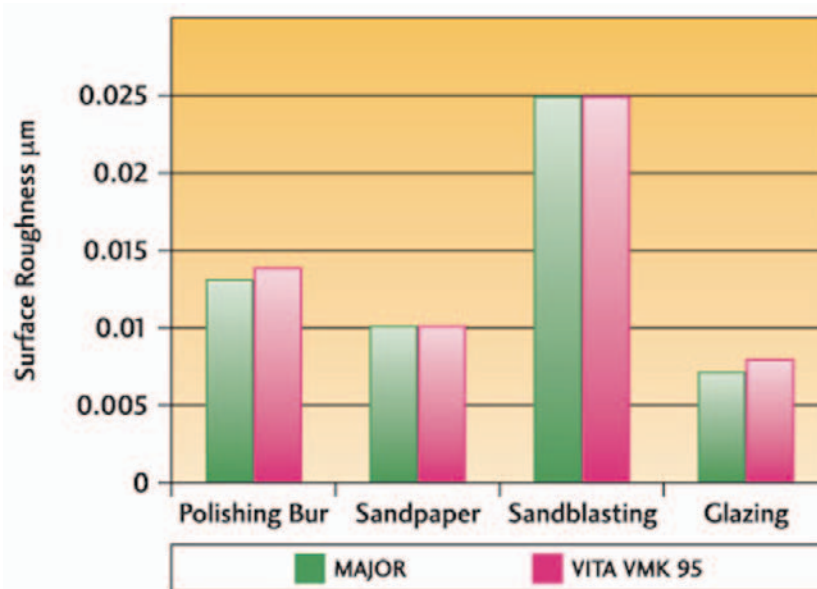


Figure 3. Bar chart according to the mean values of surface roughness in μm .

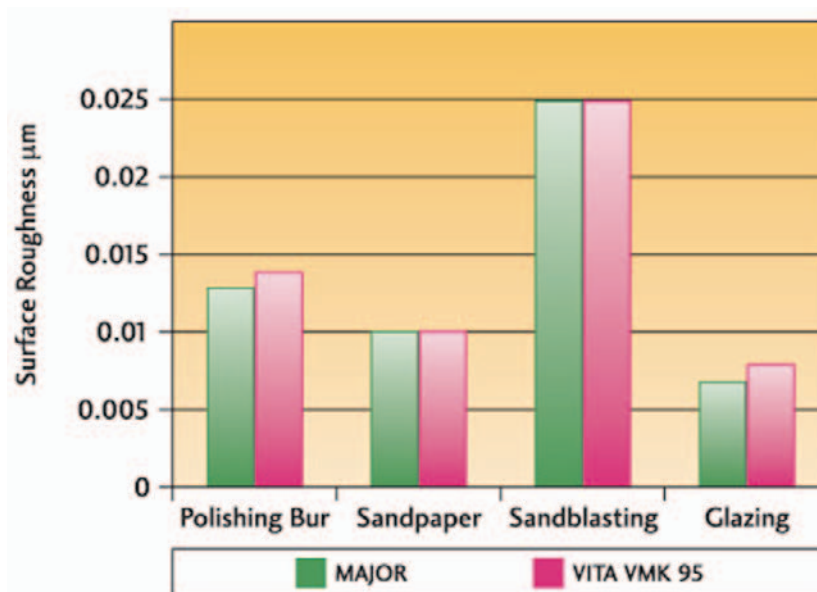


Figure 4. Bar chart according to the mean values of bacterial count in $\text{CFU} \times 10^3$.

irregularities inducing adhesion of bacteria and other substances. These superficial defects such as voids and microcracks on the subsurface of porcelain serve as possible sites for bacterial adhesion and colonization.² Initial colonization of bacteria can easily occur in the depth of surface irregularities and it is difficult to completely remove plaque from these grooves that facilitate reaccumulation.¹⁸ Voids or pores can present even on the subsurface of smooth porcelain surfaces and bacterial adhesion to the glazed porcelain surfaces can be attributed to these defects.²

Another explanation to the effect of surface roughness on the attachment of biofilm bacteria is that more or less “surface” is available for bacterial attachment and more or less protection is provided for colonizing bacteria.^{19,20}

Less plaque adhesion might suggest a clinically smoother surface. Therefore, measuring the amount of plaque accumulation on the porcelain restoration could be a good index for judging whether the respective polishing method can achieve less plaque adhesion. The glazed



porcelain surface was the smoothest and showed a significant difference in roughness value compared to the sandpaper and silicon bur polishing method and a highly significant difference compared with the sandblasted porcelain surface.

The application of glazing material after grinding will eliminate various defects and flaws from the treated porcelain surface, causing an increase in smoothness of the surface.

The sandpaper used in the study was adopted for obtaining a flat, uniform surface with no undulations. Using finer grit can obtain a smoother porcelain surface.² The highest surface roughness values in the sandblasted specimens were related to the impact of the sand particles with the surface. This created an array of deep grooves and valleys around the impact site, which increased the roughness values. The cracking associated with such treatment leads to the development of median, radial, and lateral cracks. The lateral cracks result in material removal and the resultant surface roughness.¹⁶

Conclusions

Under the conditions of this *in vitro* study, the following conclusions can be drawn:

1. A positive correlation was found between the surface roughness value of porcelain and the amount of *S. mutans* adhesion to these surfaces irrespective of the material type and the surface finishing method used.
2. Glazed porcelain was the smoothest surface and exhibited the least amount of *S. mutans*

adhesion among the four surface finishing methods used. From a biologic point of view, glazing is a more acceptable way to finish the surface of porcelain.

Clinical Significance

Chairside adjustments of the cervical contour or occlusal surface of porcelain restorations are sometimes necessary before or after cementation. Ideally, an uncemented restoration should be returned to the laboratory for reglazing after all adjustments have been completed.

It is important to evaluate various polishing procedures used for these adjusted surfaces to achieve a finished surface that as closely as possible approximates the quality of glazed porcelain.

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