Altered bacterial adhesion with changes in roughness of titanium surfaces after implant cleaning

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ABSTRACT

Although various instruments have been devised to treat peri-implantitis, none has become the technique of choice. Recently, a new implant cleaning bur was introduced. We compared the surface roughness and bacterial adhesion on implants after surface cleaning with various instruments. Two types of titanium disks – resorbable blasting media (RBM) and sandblasting with large grit and acid etching (SLA) – were used. Following treatments were administered: (1) no treatment; (2) tetracycline; (3) implant cleaning bur; (4) air polisher with glycine powder; and (5) copper alloy ultrasonic scaler tip. We measured the titanium surface roughness after cleaning. We also observed surface changes with scanning electron microscopy, and evaluated the bacterial adhesion related to changes in surface roughness. The surface roughness of RBM disks decreased significantly only in the third group. SLA disks in the third and fifth groups showed significantly decreased roughness. No significant difference in bacterial adhesion was found on treated RBM surfaces. The third and fifth groups also had significantly decreased bacterial adhesion on the SLA surfaces. The implant cleaning bur reduced the roughness of RBM and SLA titanium implants, and decreased the adhesion of bacteria on SLA surfaces, which may help prevent the recurrence of peri-implantitis.

KEY WORDS: Biofilms, Bacterial adhesion, Dental implants, Peri-implantitis, Scanning electron microscopy

Introduction

Dental implants replace missing teeth in periodontally compromised patients. Osseointegration between the implant and the supporting bone is essential for the success of dental implants, and implant surface modification has been investigated with the goal of improving osseointegration. Compared with machined surfaces, rough implant surfaces reportedly exhibit improved bone-implant contact [1-4]. Peri-implantitis is an inflammatory reaction associated with the loss of supporting bone around a functioning implant [5]. Many previous studies have demonstrated that the formation of dental biofilm on implant surfaces initiates inflammation in the peri-implant mucosa [6]. The removal of this dental biofilm is crucial for the prevention of peri-implantitis.

Numerous studies have demonstrated that increased surface roughness leads to greater bacterial adhesion [7-10]. Berglundh et al. [11] demonstrated that the progression of peri-implantitis associated with implants with rough surfaces is more pronounced than that associated with implants with machined surfaces. Bürgers et al. [12] reported that initial bacterial adhesion is influenced by surface roughness. When implant surfaces are exposed to the oral cavity as a result of peri-implantitis, greater amounts of dental biofilm may accumulate on rougher surfaces, exacerbating peri-implantitis.

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Attempts to clean exposed implant surfaces have been made as part of the treatment for peri-implantitis. Some researchers observed that mechanical debridement with conventional metal curettes or ultrasonic scalers with stainless-steel tips damages implant surfaces, which may create environments that facilitate the adhesion of new dental biofilms [13,14]. This finding led to the development of new cleaning instruments that do not scratch titanium surfaces. The use of plastic curettes or ultrasonic scalers with plastic tips produces no definitive signs of damage [15,16]. However, these methods may not clean implant surfaces sufficiently [17]. The use of air polishers on implant surfaces does not significantly change surface roughness [18-20]. However, the use of sodium bicarbonate (SB) with air polishers results in deposits of powder and cratering, as observed with scanning electron microscopy [19]. Although these problems have been eliminated by the use of water-soluble glycine powder (GP), the air polisher method remains ineffective for reducing surface roughness [20]. Recently, novel copper alloy (CA) scaler tips have been developed, which has lower with strengths than pure titanium. These scaler tips reportedly do not alter surfaces and hence cause no surface damage [14]. However, there have been no studies of the relationship between the use of these tips on bacterial adhesion.

The above-mentioned challenges have led to the development of methods to reduce surface roughness. One such method is the use of an implant cleaning bur (ICB) composed of many strands of wire. Using an ordinary bur on an implant removes the implant thread. By contrast, ICBs do not remove threads while smoothing rough implant surfaces. Hence, ICBs might be useful for removing biofilm and preventing its recurrence.

Despite this expectation, no report has examined whether ICBs significantly reduce surface roughness and if so, whether that reduction in turn lowers bacterial adhesion to the surface. In this study, we examined the effects of various cleaning instruments on surface roughness and determined whether reductions in surface roughness influenced bacterial adhesion to implant surfaces.

Table 1. Treatment protocol for each instrument

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Protocol</th>
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<tr>
<td>Tetracycline</td>
<td>50 mg/ml, burnished with cotton pellet for 3 min, and rinsed for 3 min [21].</td>
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<tr>
<td>Implant cleaning bur</td>
<td>Used until the RBM or SLA surface was removed with the rotatory instrument at 800 rpm.</td>
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<tr>
<td>Air-polisher</td>
<td>20 sec at 5 mm distance from the surfaces, washed with an air-water spray [20].</td>
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<tr>
<td>Copper alloy ultrasonic scaler</td>
<td>Conventional ultrasonic scaler used for 30 sec at 40% of full power [14].</td>
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Materials and Methods

Titanium disk preparation
Two types of commercially pure titanium disk (Grade IV), each measuring 5 mm in diameter and 1 mm in thickness, were used: (1) a resorbable blasting media (RBM) disk, and (2) a disk that was sandblasted with large grit acid etching (SLA). Ten samples were prepared for each treatment group as follows: (1) no treatment (control); (2) tetracycline treatment; (3) ICB (I.C.T®️, HANS, Seoul, Korea) treatment; (4) air polisher with GP (Air-Flow®️ S1, EMS, Nyon, Switzerland) treatment; and (5) CA ultrasonic scaler tip (IS tip®, B & L, Seoul, Korea) treatment. The surfaces of the disks were treated with the various implant cleaning instruments (Fig. 1). The protocols for each surface treatment method are listed in Table 1.

Surface roughness measurement
The roughness of the titanium disk surfaces was evaluated with a SurfTest SJ-400 (Mitutoyo, Kawasaki, Japan). The Ra values of the disk surfaces were measured.

Bacterial adhesion assay
Streptococcus gordonii DL1 was used for the adhesion assays. S. gordonii is an initial colonizer which is a pivotal...