

Comparison of the effects of various periodontal rotary instruments on surface characteristics of root surface

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Abstract: The efficacy of scaling and root planing using various periodontal rotary instruments was examined. Eighty extracted human teeth with a history of periodontal disease were divided into four groups of 20 and subjected to one of the following procedures: Use of 1) a Root Burnisher, 2) a Perio Planing Bur (both rotating instruments for contra angle handpieces), 3) a Tooth Planing Bur (rotating instrument for use with an air turbine), or 4) a Gracey Scaler. In each case, the time required for cleaning was measured. Twenty healthy extracted human teeth were used as untreated controls. After treatment, the surface roughness of 10 specimens out of each group were measured using a profilometer and observed by scanning electron microscopy (SEM). Half of the samples were then incubated in dishes with a suspension of fibroblasts. After counting the number of attached cells, the attachment of fibroblasts was observed by SEM. The root surfaces treated with the rotary instruments appeared smooth and there were no significant differences between groups. From the SEM observations, smooth root surfaces with different surface textures were evident and a tight attachment of fibroblasts was observed. The results of this study suggest that use of rotary instruments is superior for periodontal scaling and root planing. (*J. Oral Sci.* 46, 1-8, 2004)

Key words: rotary instrument; roughness; fibroblast; periodontal disease.

Introduction

Bacterial plaque and calculus are recognized etiological agents in the initiation and progression of periodontal disease (1), and their accumulation and attachment are facilitated by a roughened root surface (2-6). Scaling and root planing to produce smooth root surfaces, together with brushing instructions, are thus an essential component in both treatment and prevention of periodontal disease (7). The instruments currently available for scaling and root planing are hand scalers and ultrasonic scalers. Although hand scalers are frequently used, considerable time and manual dexterity are required for their effective operation (7). Moreover, hand scalers are unable to reach the deeper root surfaces when the periodontal pockets are more than 4 mm deep (7,8). Consequently, ultrasonic scalers have become more widely used in recent years. Although they are simpler to use, it is often difficult to achieve a smooth and calculus-free root surface (9-11), and dental plaque adheres more readily to the roughened root surfaces created by the use of an ultrasonic scaler (12). To overcome these challenges associated with use of ultrasonic scalers and hand scalers, rotary instruments for scaling and root planning have been developed. Previously, a carbide bur and a diamond point were used at high-speed rotation for polishing. However, these rotating instruments have been reported to be associated with an increased risk of damaging the root surface and soft tissues (13). The roto sonic scaler, in which a hexagonal pyramid chip is installed on an air turbine for high-speed rotation, can damage the gingival

tissues or the dentin if used incorrectly, and this instrument is thus no longer in general use (14,15). Recently, other rotary instruments have been developed for scaling and root planing, and their effectiveness in the clinical situation evaluated (16-18). The purpose of this study was to compare the efficacy of the several rotary instruments in scaling and root planing, and to compare with use of a Gracey Scaler. The hypothesis was that the rotary instruments for scaling and root planing would be more efficacious than a hand scaler.

Materials and Methods

Rotary instruments

Two rotary instruments for contra angle handpieces (Root Burnisher, SU-2, Seven Hills, Tokyo, Japan; Perio Planing Bur, 831EF, Brasseler, Georgia, USA) (Fig. 1), a

rotary instrument designed for use with an air turbine (Tooth Planing Bur, No.2-L, Tokyo Shizaisha, Tokyo, Japan) (Fig. 1), and a hand scaler (Gracey-curette scaler 5/6, Hu-Friedy, Chicago, USA) as a control, were used.

Teeth

Human teeth with a history of periodontal disease were employed. The teeth were single-rooted teeth with similar deposits of calculus (as assessed by the naked eye), and had been extracted from individuals with no previous history of periodontal treatment during orthodontic treatment. After extraction, the teeth were washed in normal saline and frozen at $-20 \pm 4^\circ\text{C}$ (19). Teeth that had undergone root-canal treatment or had any apical lesions or caries were excluded.

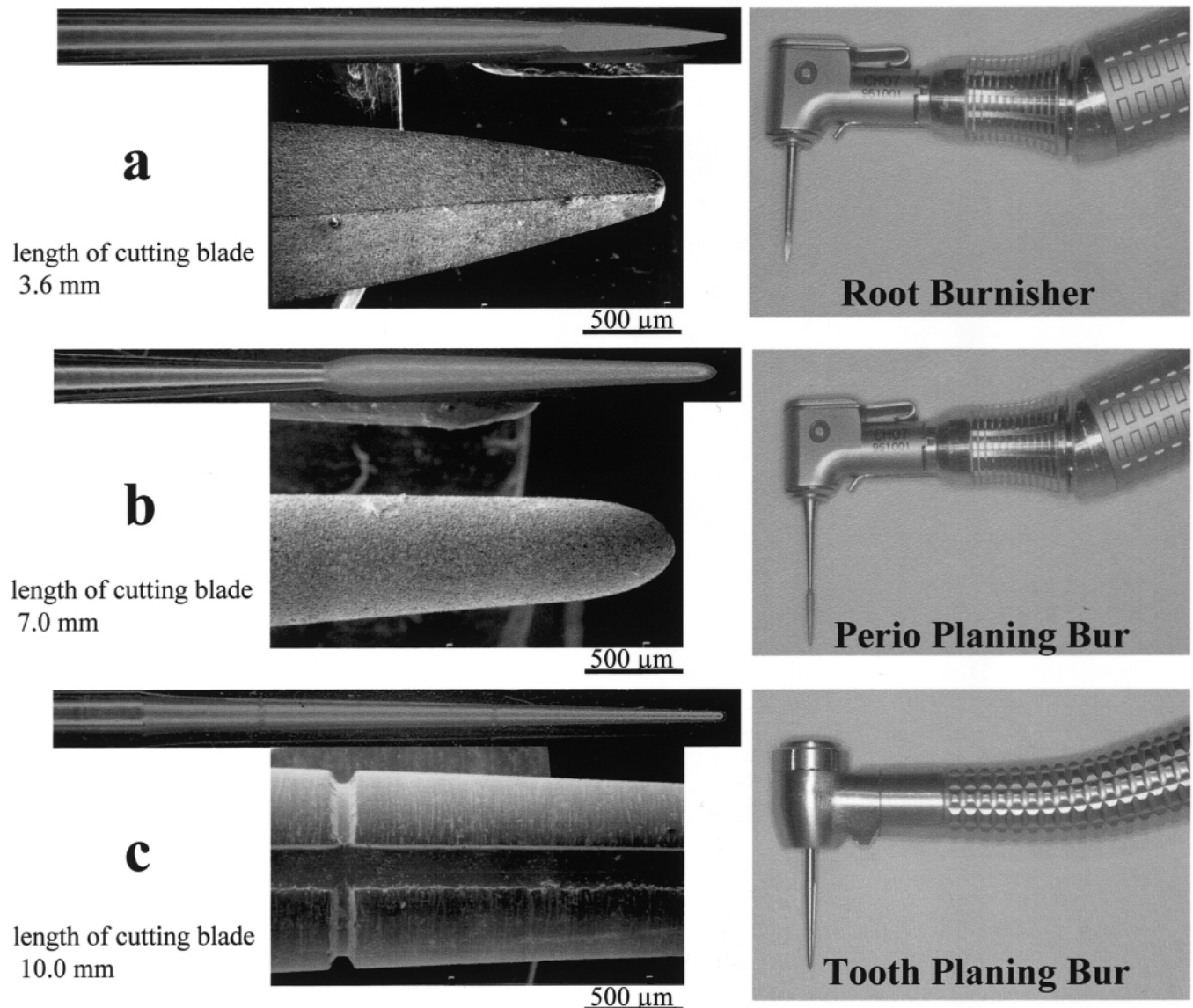


Fig. 1 Periodontal rotary instruments used in this study, (a) Root Burnisher, (b) Perio Planing Bur, (c) Tooth Planing Bur.

Preparation of specimens

The teeth were defrosted at room temperature, and sections of $5 \times 5 \times 1$ mm were removed from the cemento-enamel junction to the root apex using a water-cooled dental turbine. Calculus attachment to the root surfaces was evaluated with a $60 \times$ stereomicroscope (SZH-ILLD, Olympus, Tokyo, Japan) using a 10×10 micrometer attached to an ocular lens (7). Eighty specimens that were 50% covered with calculus were selected. In addition, 20 teeth expediently extracted during orthodontic treatment were used as healthy control. All specimens were immersed in 2% hypochlorous acid solution and the soft tissue was removed (12). The specimens were divided into four groups (Root Burnisher, Perio Planing Bur, Tooth Planing Bur, and Gracey Scaler group), each containing 20 specimens. Scaling and root planing were performed with water cooling at 0.98 N (100-gf) pressure for the Root Burnisher and Perio Planing Bur groups, 0.49 N (50-gf) pressure for the Tooth Planing Bur group and 4.90 N (500-gf) pressure for the Gracey Scaler group with the samples mounted on a force gauge (DPX-5T, Imada, Tokyo, Japan) (20,21). Rotation speed was 20,000 rpm with the use of the Root Burnisher or Perio Planing Bur, and 300,000 rpm with the use of the Tooth Planing Bur (16). Scaling and root planing were performed until the root surface appeared smooth upon visual inspection and examination with a periodontal probe. Healthy root specimens were rinsed in 0.2 M PBS (pH 7.2) and classified as untreated controls.

Measurement of the time required for scaling and root planing

The length of time required for scaling and root planing with each instrument was measured at 5-second intervals by staff members, and the average time for each group was calculated.

Surface roughness

Arithmetical mean deviation of the profile (Ra; JIS B 0601, 1994) and ten point height of irregularities (Rz; JIS B 0601, 1994) of 10 specimens out of each group were measured by means of the surface roughness and shape measurement system (Surfcom 1400 A, Tokyo Seimitsu, Tokyo, Japan). The measurement was performed with a 0.25-mm cutoff and 1.25-mm measurement length. Each specimen was measured five times at 0.5-mm intervals lengthwise and widthwise, and the average measurements for each specimen were calculated.

Cell culture

For measurement of cell attachment to the root surface,

MRC-5 fibroblasts (The Japan Health Science Foundation, Tokyo, Japan) originating from human were used. The culture medium was α -MEM, and contained 10% fetal bovine serum (Bio fluids, Bio source international, USA) and antibiotics (penicillin/streptomycin solution, Sigma-Aldrich, St. Louis, USA; final concentration 50 U/ml penicillin and 50 μ g/ml streptomycin). The fibroblasts were cultured at 37°C under 5% CO₂ and 95% air and were used after four or five transfers, when the doubling time had become constant.

Ten remaining specimens out of each group were sterilized using ethylene oxide gas. After sterilization, they were placed into 24-well dishes (3047, Falcon, Becton, Dickinson, NJ, USA) with the cultured cells, which were diluted to a density of 1.0×10^4 cells/ml. A 24-hour culture was performed on each group of cells, under the following conditions: $37 \pm 0.5^\circ\text{C}$, 5% CO₂, 95% air, pH 7.4.

Measurement of the number of attached cells

Ten specimens from each group, where the cultured cells attached, were then washed twice in 0.2 M PBS (pH 7.2), fixed using the procedures described above, and stained with 0.1% toluidine blue solution. The numbers of attached cells were measured at 5 random areas on each specimen surface using a $60 \times$ stereomicroscope (SZH-ILLD, Olympus, Tokyo, Japan) and a 10×10 micrometer attached to an ocular lens. The number of cells appearing on the 16 grids of the diagonal line were counted and converted to the number per 1 mm². The average of the 5 randomly selected areas was considered the number of attached cells per specimen after a 24-hour culture (22).

Observation of the surface texture and the attached cells on the root surface

All specimens were fixed for 1 hour in 1% glutaraldehyde in PBS solution, and rinsed in PBS. The specimens were then postfixed for 1 hour in 1% osmium solution in PBS, rinsed in PBS, dehydrated in an ascending ethanol series, substituted with isoamyl acetate, processed with a critical point dryer (HCP-2, Hitachi, Tokyo, Japan), and gold coated with an ion coater (JFC-1100, JEOL, Tokyo, Japan). The root surface texture and cell attachments were observed by scanning electron microscopy (SEM) (S-4300, Hitachi, Tokyo, Japan).

Statistical analysis

In this study, all measurements and observations, with the exception of measurement using the profilometer, were completed independently by three examiners. None of these examiners took part in the experimental procedures.

Statistical analysis performed using a one-way factorial ANOVA and Scheffe test. A probability of less than 5% was considered statistically significant.

Results

Time required for scaling and root planing

Time required for treatment using a Tooth Planing Bur or Gracey Scaler was significantly longer than that required with a Root Burnisher or a Perio Planing Bur, but there was no significant difference in time required between the Tooth Planing Bur and Gracey Scaler groups (Fig. 2).

Measurement of surface roughness

The roughness of the root surfaces (parameters Ra and Rz) treated with the different test instruments was similar, with no significant differences between groups (Fig. 3).

Observation of root surface texture

The root surface cementum of the untreated control group appeared dome-shaped (Fig. 4). At high magnification, numerous scratches were observed on the root surface in the Perio Planing Bur and Tooth Planing Bur groups (Fig. 4), while a smooth surface with cracks was observed in the Root Burnisher group (Fig. 4). A relatively thick smear layer was observed on the root surface in the Perio Planing Bur, Tooth Planing Bur and Gracey Scaler groups, and it was difficult to distinguish between cementum and dentin. The smear layer covered root surface in the Gracey Scaler group and revealed different texture (Fig. 4).

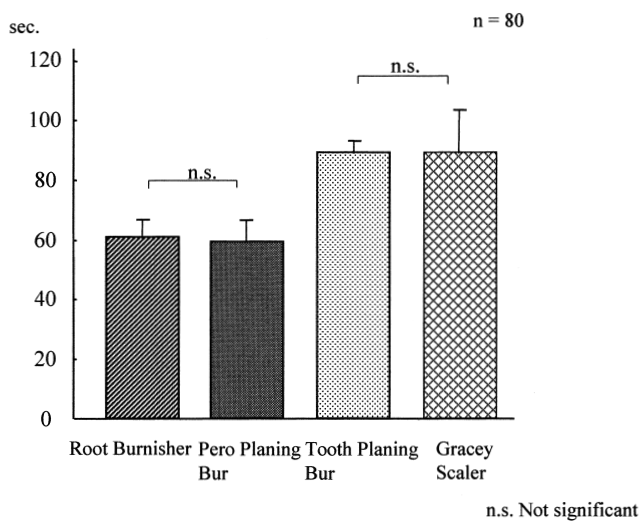


Fig. 2 Mean time (in seconds) required to clean the root surface with each instrument. The time required to clean the area of interest was shortest when either the Root Burnisher or Perio Planing Bur was used.

Number of attached cells

The number of attached cells did not differ significantly between groups (Fig. 5). The number of attached cells in the control group was not significantly different from that in experimental groups.

Morphological appearance of attached cells

The SEM pictures of the cells attached to the root surfaces treated with three kind of rotary instruments revealed long, wide, and planar cytoplasmic projections and extending numerous filopodia. The appearance was similar to that in the untreated control group (Fig. 6). In the Gracey Scaler group, long extended cytoplasmic projections and very short extended filopodia were observed (Fig. 6).

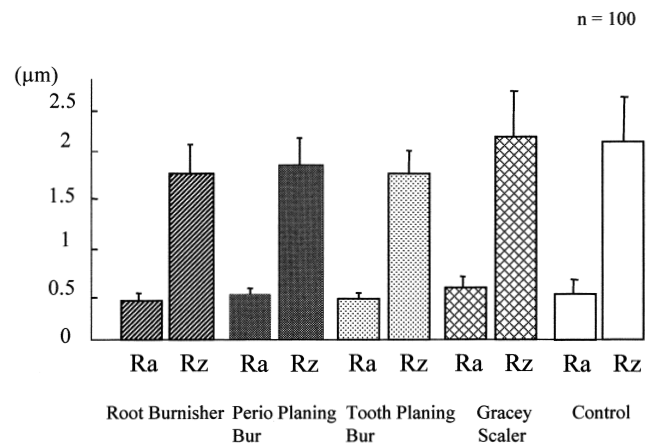


Fig. 3 Mean Ra and Rz values for the treated root surfaces. There was no significant difference between groups.

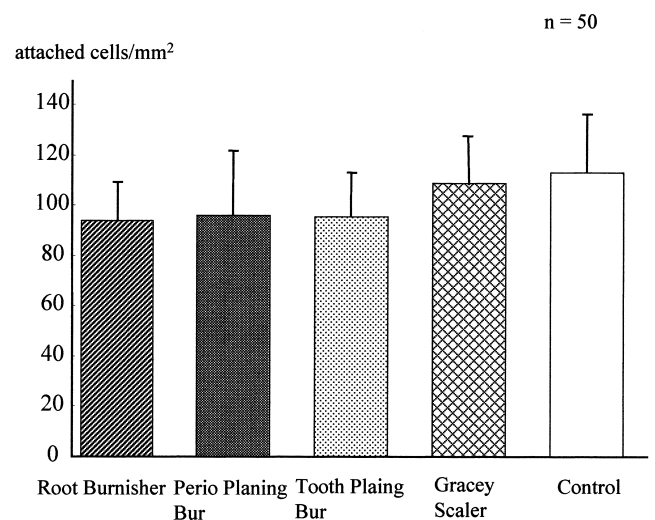


Fig. 5 The number of attached cells on the treated root surfaces (no significant difference between groups).

Discussion

In the current study, the time required for scaling and root planing using the rotary instruments and a Gracey Scaler were compared and it was apparent that use of a Tooth Planing Bur or a Gracey Scaler was more time consuming than in the case of a Root Burnisher or Perio Planing Bur. These results suggest that the cutting efficiency of the Root Burnisher and Perio Planing Bur are higher than the other instruments employed.

The surface roughness of the root surfaces treated with three kind of rotary instruments was similar to that following use of a Gracey Scaler. Although similar Ra and Rz values were obtained across groups, post-treatment SEM pictures

revealed surface textures differed between groups. Dome shaped cementum was observed in the case of intact root surfaces, but the root surfaces treated with a Gracey Scaler exhibited scarry roughness.

The root surface treated with a Gracey Scaler was covered by a smear layer and a small amount of dental calculus remained, in line with previous findings (7). Root surfaces treated with a rotary instrument appeared flat and glossy to the naked eye. However, SEM pictures revealed a roughened and scratched root surface where a Perio Planing Bur or Tooth Planing Bur had been used, but a smoother surface with smaller cracks where a Root Burnisher had been employed. The Tooth Planing Bur

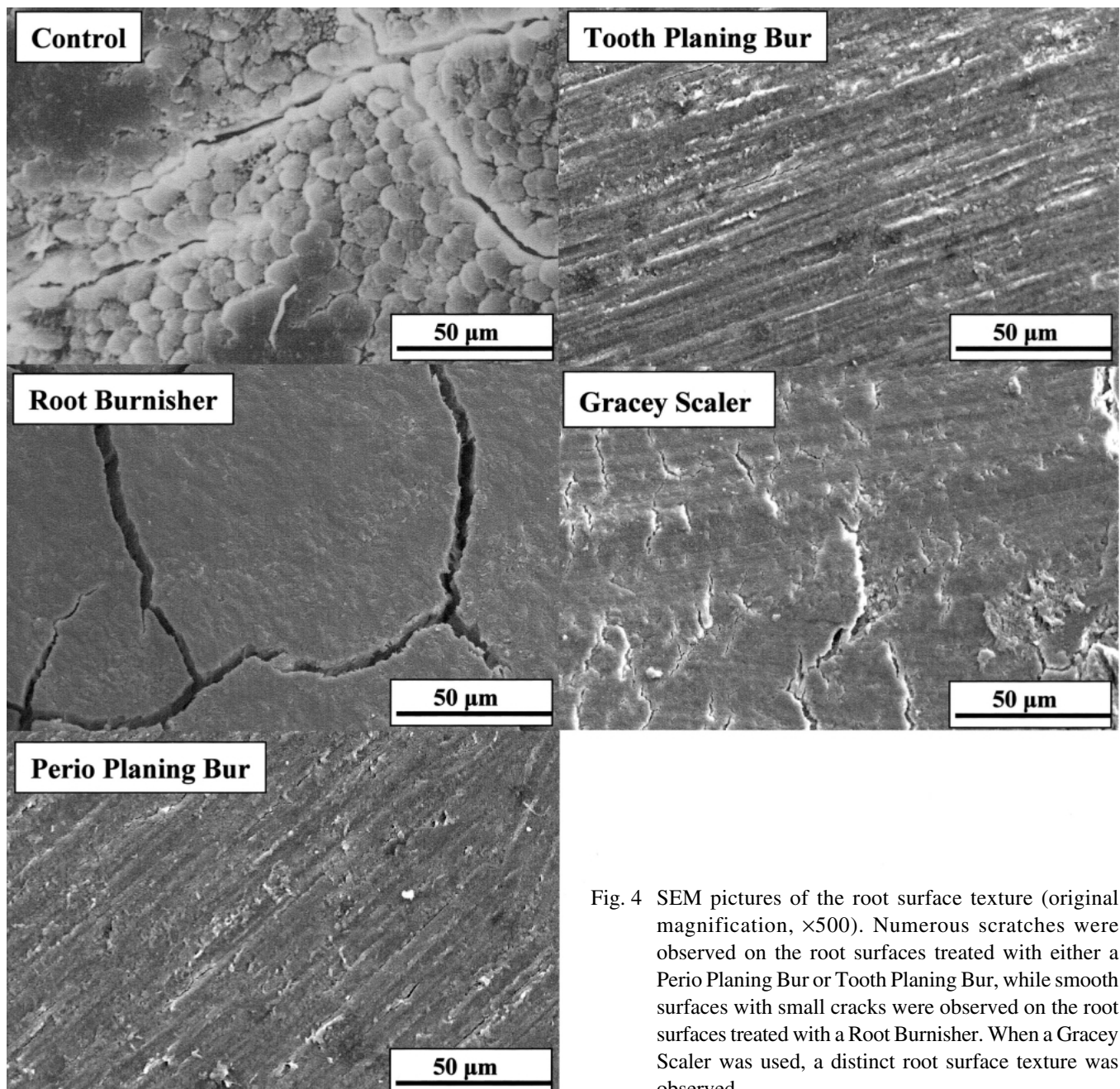


Fig. 4 SEM pictures of the root surface texture (original magnification, $\times 500$). Numerous scratches were observed on the root surfaces treated with either a Perio Planing Bur or Tooth Planing Bur, while smooth surfaces with small cracks were observed on the root surfaces treated with a Root Burnisher. When a Gracey Scaler was used, a distinct root surface texture was observed.

possesses two vertical flutes that could be responsible for the SEM appearance. The Perio Planing Bur exhibits the same cutting trace as the Tooth Planing Bur. Although the surface texture of the treated root surfaces differed, surface roughness between groups were not significantly different. In the current study, it was necessary to use a relatively shorter measuring distance to measure surface roughness with the profilometer, since the sample was not completely flat. This may in part explain the findings of no significant difference between groups in this regard.

The Root Burnisher has a square shaped cutting blade without flutes or a diamond-coated surface. The edge of the cutting blade might increase removal of attached

calculus from the root surface, creating a smooth root surface evident in the SEM pictures. However, the slow-speed cutting with this blade might encourage ductile fracture due to plastic deformation of the cementum and dentin substrate, and subsequent crack propagation on the root surface.

Different root surface textures were observed between groups by SEM, but it was unclear whether any could be considered “clean”. Since periodontal microbiota and bacterial endotoxins contaminate root surfaces and inhibit migration and attachment of fibroblasts (23,24), we cultured fibroblasts on these surfaces for 24 hours, and examined their numbers and status of their attachment to the root

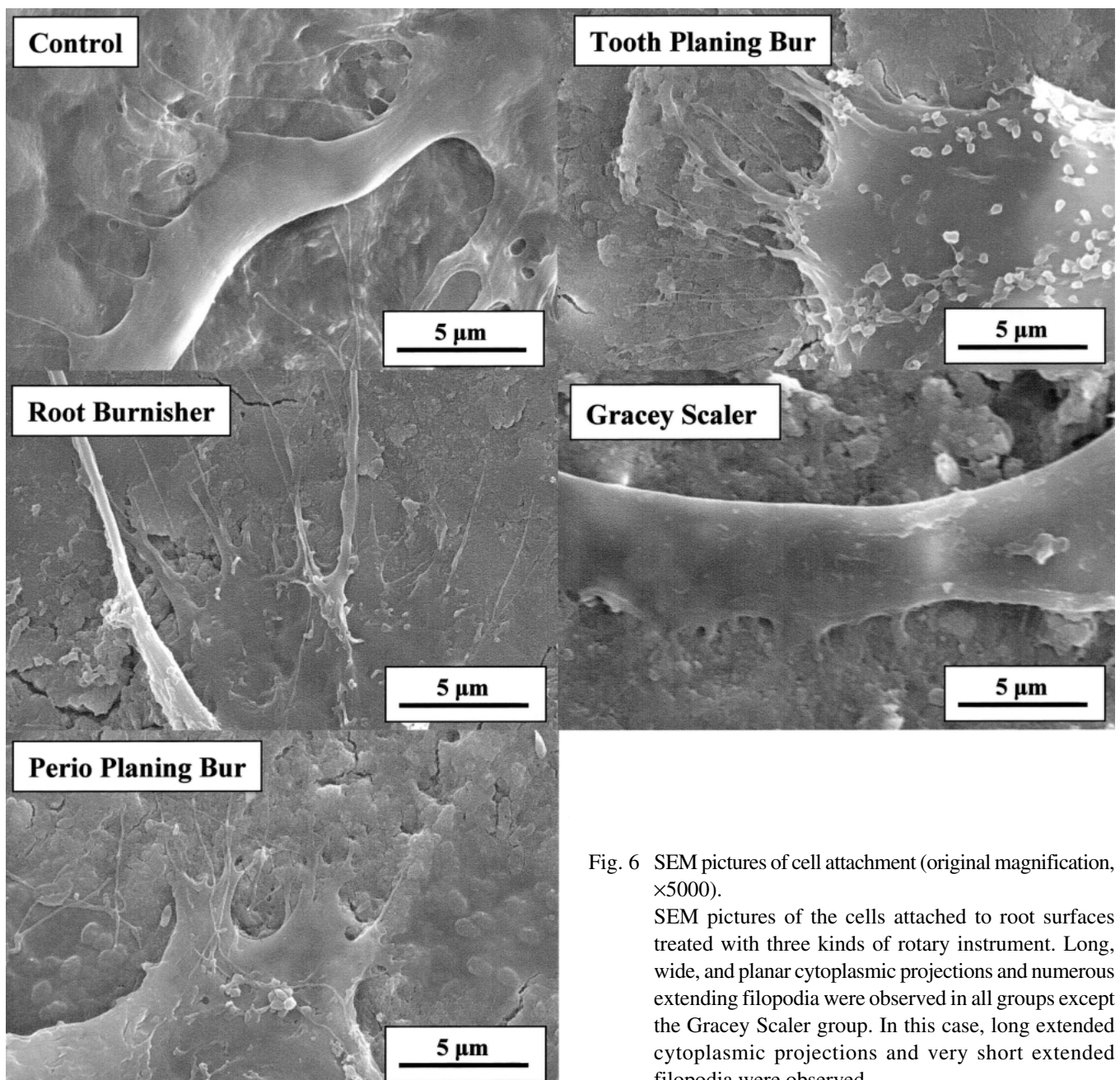


Fig. 6 SEM pictures of cell attachment (original magnification, $\times 5000$).

SEM pictures of the cells attached to root surfaces treated with three kinds of rotary instrument. Long, wide, and planar cytoplasmic projections and numerous extending filopodia were observed in all groups except the Gracey Scaler group. In this case, long extended cytoplasmic projections and very short extended filopodia were observed.

surface.

There were no significant differences in the number of attached cells between groups and compared with the untreated control group. This might be due to the substantial removal of contaminants, such as endotoxins, from the surface of the samples. Surface texture, including scratches created due to cutting, had no effect on cell attachment. Interestingly, from a morphological perspective, a favorable attachment with the creation of cytoplasmic projections with active extensions of filopodia was seen where the root surface had been treated with a Root Burnisher, Perio Planing Bur or a Tooth Planing Bur. The same tendency was evident in the case of the intact root surface. Where the root surface had been treated with a Gracey Scaler, however, poor extensions of filopodia were observed with elongation of the cytoplasmic projections. It has been reported that an acceptable connective tissue attachment is created by performing a thorough scaling and root planing with a hand instrument (25). Such a difference in attachment might be due to the use of more efficacious rotary instruments in the current study. As evident from the SEM pictures, qualitative and quantitative differences in the morphology of the smear layer might have resulted in disruption of the connective tissue attachment. Since there was no significant difference in surface roughness between groups, residual contaminants such as endotoxins on the root surface might be the cause of these morphological differences.

From the results of the present study, it appears that rotary instruments can create as smooth a root surface as found in the case of a non-diseased root when measured with the profilometer. When these root surfaces were observed by SEM, surface textures differed with treatment method, and these differences might affect cell attachment to the treated root surface. Further studies are needed to determine the cutting efficiency and effectiveness of the rotary instruments for root surface scaling, and the effect of the surface profile after scaling and root planing on cell attachment.

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