A preliminary study on the usefulness of fiberscope for subgingival periodontal treatment

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Purpose: Direct, real-time visualization of subgingival area may improve the efficiency of subgingival treatment. The purpose of this study was to evaluate the usefulness of the fiberscope (FS) for subgingival periodontal treatment.
Materials and Methods: The original jaw model in which the artificial teeth were uniformly coated with nail enamel was attached to a simulator head. The experimental teeth were painted on the root surfaces of #12, #13 and #14, and in the furcation of #46. Three types of the FS (3,000 pixels, φ1.0 mm) with working or irrigation channel were used. The operators were eight dentists (four experienced and four beginning clinicians for using a FS). The experimental teeth were performed scaling and root planing (SRP) with and without FS. Furthermore, the experimental part which are difficult to adapt periodontal instruments were irradiated with Nd:YAG laser (100 mJ, 15 pps) using the FS, only by the experienced clinicians. Then each root surface was observed to analyze the residual nail enamel.
Results: The residual rate in FS group was significantly lower than that in non-FS group on the labial root surface of #12 and in the furcation of #46 ($p<0.05$). Also, it was possible to remove nail enamel by Nd:YAG laser irradiation using the FS.
Conclusion: The results suggest that the application of FS for subgingival periodontal treatment leads to better outcome in comparison with conventional periodontal treatment without FS.
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Key Words: fiberscope, Nd:YAG laser, root planing, scaling, subgingival periodontal treatment

Introduction

Nowadays many endoscopic systems with fiberscope (FS) are widely used in the field of medicine for clinical diagnosis and treatment.[1,2] However in dentistry, this system has not been so popular as yet. Numerous studies have shown that subgingival plaque and calculus are related to destructive periodontal disease.[3-6] Therefore, the removal of bacterial plaque and calculus is an important aspect of all periodontal therapy.[7,8] However, the inability of the clinician to scale and plane the subgingival root surface completely has been repeatedly demonstrated.[6,9-12]

Scaling and root planing (SRP) are important methods of periodontal therapy which are difficult to master. The difficulties in accomplishing proper debridement increase with increasing depth of periodontal pocket, the presence of root fissure, root concavity and furcation in the subgingival area. But, direct, real-time visualization of subgingival hard and soft tissue may improve efficiency of subgingival treatment. So, we have been developing an original endoscopic system with FS since 1996 to employ it in clinical dentistry, especially for periodontics and endodontics.[13,14] This system is very useful for observing the subgingival root surface in carrying out periodontal treatments. The purpose of this study was to evaluate the usefulness of the FS for subgingival periodontal treatment.

Materials and Methods

Original jaw model and experimental teeth

The original jaw model (Koken, Tokyo, Japan)[15] in which the artificial teeth were uniformly coated with a layer of nail enamel was attached to a simulator head. This original jaw model (Fig. 1) can allow the fundamental examination of periodontium such as probing pocket depth (PPD), tooth mobility and so on. Some degree of bone resorption is also observed on this model as indicated in the attached X-ray photograph (Fig. 2) that reflects the bone resorption of this model. In addition, morphological abnormalities of the teeth and adjacent soft tissues, such as high frenal attachments, tension ridge, festoon, cleft, lingual groove (#12) and enamel projection (#46) are also reproduced on it (tooth numbering: FDI Two-Digit Notation). Lower left side of the original jaw model represents normal gingiva and alveolar bone. Upper left side presents abnormal gingiva and normal alveolar bone (relative pocket). Right side presents some degree of bone level resorption and abnormal gingiva (absolute pocket). The experimental teeth were painted with nail enamel on the labial and palatal root surfaces of #12, the distal root surface of #13, the mesial root surface of #14 and in the furcation of #46 (Fig. 3). Table 1 shows PPD and attachment level (AL) of the original jaw model.

Table 1. Probing pocket depth (PPD) and attachment level (AL) of the original jaw model

PPD and AL of the original jaw model (mm)

Facial	AL	4	5	5	6	7	3	9	8	9
	PPD	5	6	8	9	7	9	12	10	12
			#14			#13			#12	
Palatal	PPD	5	6	5	5	4	4	10	10	11
	AL	2	3	2	3	2	2	9	8	9
Lingual	AL				5	6	5			
	PPD				5	6	5			
						#46				
Buccal	PPD				6	6	4			
	AL				7	6	5			

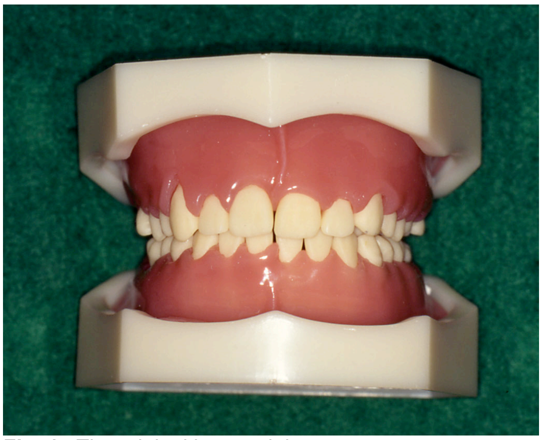

Fig. 1. The original jaw model

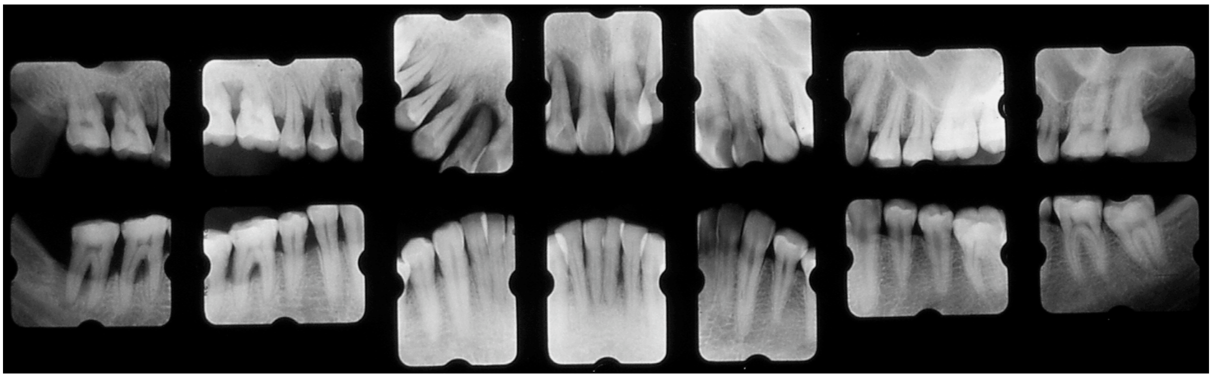

Fig. 2. X-ray photograph presenting periodontal bone resorption

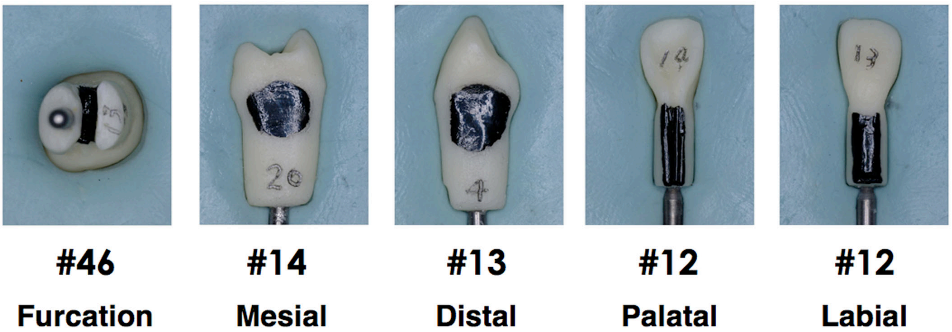

Fig. 3. The painted parts with nail enamel on the experimental teeth

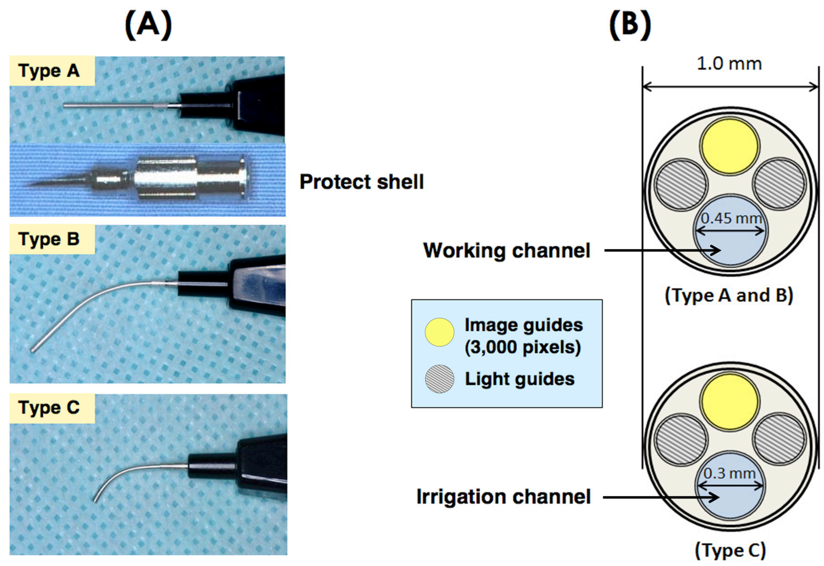

Fig. 4.
Three types of FS
(A) Form of needles
(B) Cross-section of needles

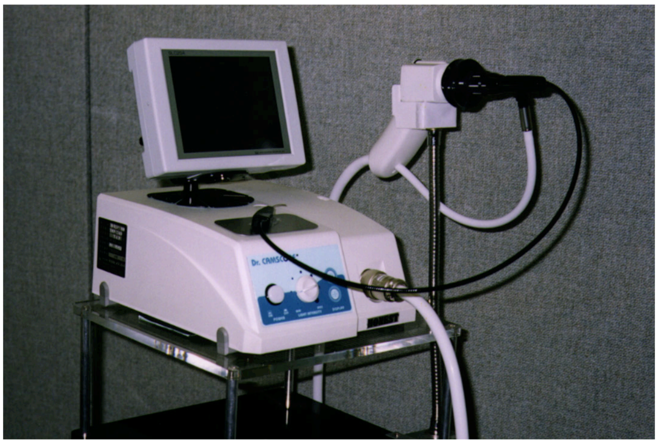

Fig. 5. Endoscopic system

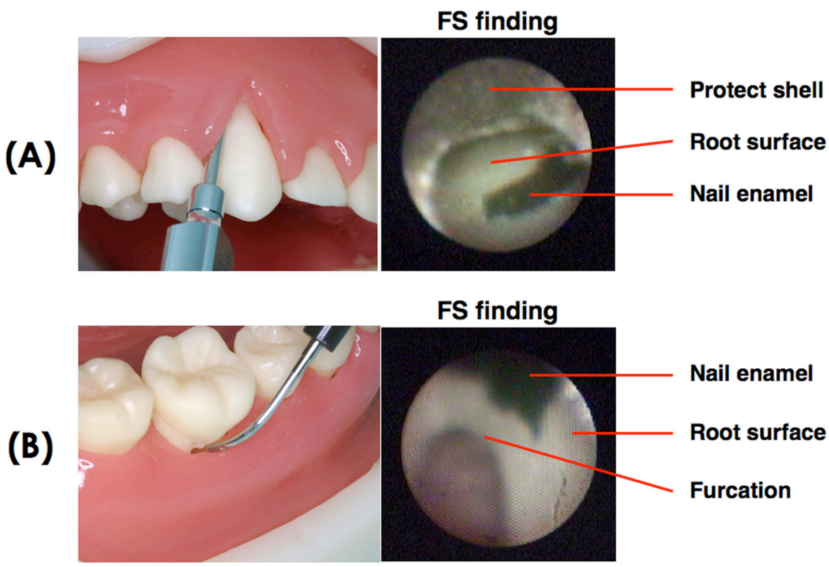

Fig. 6.
FS findings on insertion into the periodontal pockets
(A) The distal root surface of #13
(B) The furcation of #46

Endoscopic systems with FS

The FS (Solid Scope FT-711, Denics International, Tokyo, Japan) consists of image fibers (3,000 pixels) together with two light guides and a working or irrigation channel of 0.3 or 0.45 mm in inner diameter for irrigation with water and introduction of instrument. Gradient index lens was used as the lens of the FS. The lens of the FS has a nominal 70° field of view. The FS is adjusted so that a field between 0.8 mm and about 1.5 mm is in focus. And the magnification is approximately 30x in a monitor, depending on the distance of the object from the tip of the FS. Three types of needles with an outer diameter of 1.0 mm were used in this study. Type A was straight. Then, type B had a gradual curvature and type C with a more acute curvature. It is possible to insert a fine laser fiber and a special file through the working channel of Type A and B. A protect shell, which is a gingival retractor was added to the FS of Type A only. The protect shell was designed to avoid the fracture of FS when inserting into the pocket. This device also holds the gingival tissue away from the tip of the FS, providing a clear view of subgingival area. The diameter of protect shell is 1.6 mm. The tip of the FS and this protect shell is made of stainless steel (Fig. 4). The other endoscopic system (Dr. Comscope, Denics International, Tokyo, Japan) (Fig. 5) consists of an imaging unit, a color video monitor and a video recorder to catch the monitor image in real-time (Fig. 6).

Subgingival application for SRP

The operators were eight dentists consisting of four experienced and four beginning clinicians for FS use. The operators were instructed to treat experimental teeth only. At first, the experimental teeth were treated with conventional SRP (non-FS group). A new set of experimental teeth, which replaced treated teeth from the non-FS group, were treated with SRP using the FS (FS group). The operators performed SRP with Gracey curettes (1/2, 5/6, 9/10, 11/12, 13/14) and universal curettes (LM-Instruments, Parainen, Finland). Each treatment was carried out within 30 minutes. Then each root surface was analyzed using computerized imaging NIH (National Institutes of Health) IMAGE soft to assess the residual rate of nail enamel. The residual rate of nail enamel is expressed by means of the following formula. The residual rate of nail enamel (%) =The residual area of nail enamel after subgingival treatment /the preoperative area of nail enamel x100.

Subgingival application of Nd:YAG laser

For the experienced clinicians for using a FS, after replacing the treated teeth of #12 and #46 for new experimental teeth, the palatal root surface of #12 and the furcation of #46 were irradiated with Nd:YAG laser (Denics Laser Nd: Compact, Denics International, Tokyo, Japan) using the FS. The laser irradiation (100 mJ, 15 pps: 318.47 J/cm^2) through an optical fiber (φ200 μm) was performed under water irrigation. The optical fiber into FS was inserted into the periodontal pocket and moved up and down in order to irradiate the root surface as evenly as possible. Then each root surface was evaluated for the residual nail enamel.

Statistical analysis

The mean ± SE for residual rate of each group was calculated, and then the residual rates of nail enamel in non-FS and FS groups, the residual rate of nail enamel in non-FS and FS groups for the experienced and the beginning clinicians were evaluated. Data were analyzed with unpaired t-test at a level of significance of 5% ($p<0.05$).

Results

Fig. 7 shows the residual rates of nail enamel in non-FS and FS groups. The residual rates of nail enamel (non-FS group; FS group) were as follows: labial surface of #12 (29.84±5.26%; 12.97±3.81%), palatal surface of #12 (23.26±10.14%; 16.34±11.73%), distal surface of #13 (3.98±2.15%; 2.34±1.15%), mesial surface of #14 (0.22±0.13%; 7.37±5.18%), and furcation of #46 (28.12±4.49%; 10.64±6.05%). The residual rate in FS group was significantly lower than that in non-FS group on the labial root surface of #12 and in the furcation of #46 ($p<0.05$, n=8).

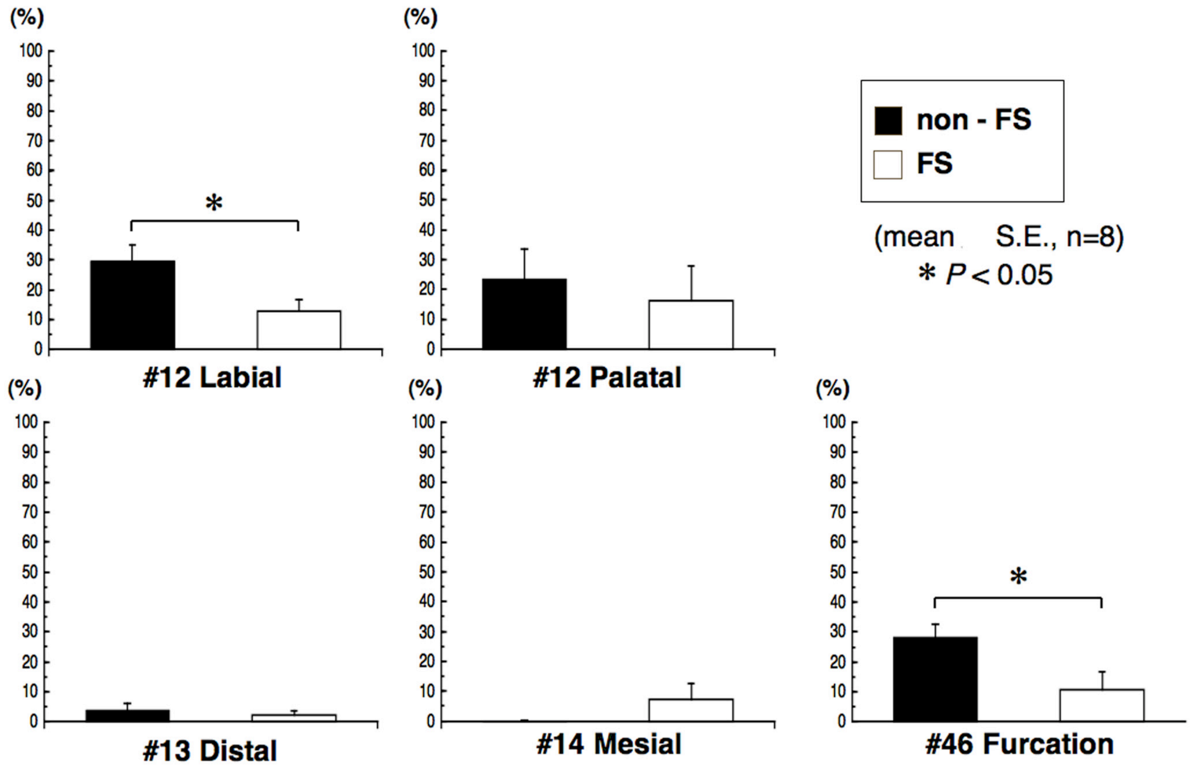

Fig. 7. The residual rates of nail enamel in non-FS and FS groups

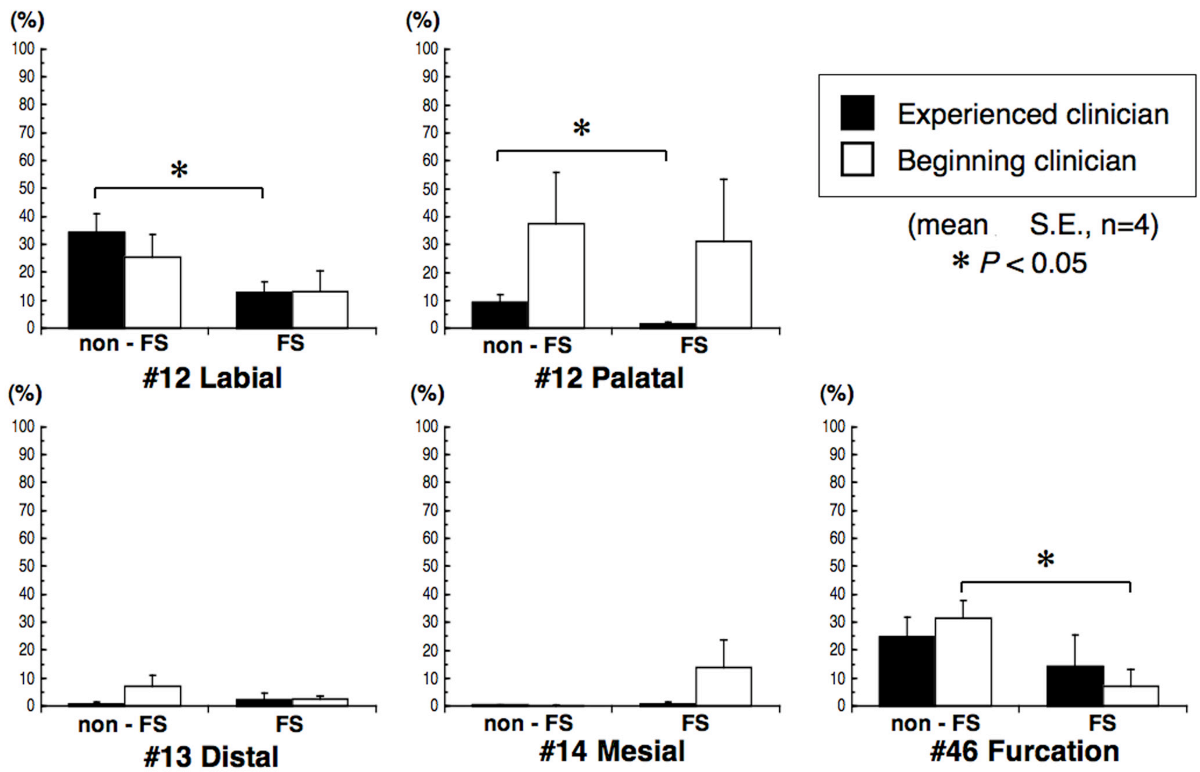

Fig. 8. Each residual rate of nail enamel in non-FS and FS groups between the experienced and the beginning clinicians for using the FS

Fig. 8 shows each residual rate of nail enamel in non-FS and FS groups for the experienced and the beginning clinicians. For the experienced clinicians, the residual rates of nail enamel (non-FS group; FS group) were as follows: labial surface of #12 (34.42±6.69%; 12.91±3.82%), palatal surface of #12 (9.13±2.85%; 1.56±0.70%), distal surface of #13 (0.91±0.64%; 2.30±2.17%), mesial surface of #14 (0.29±0.22%; 0.76±0.72 %), and furcation of #46 (24.69±6.99%; 14.14±11.30%). The residual rate in FS group was significantly lower than that in non-FS group on the labial and palatal root surfaces of #12 ($p<0.05$, n=4).

On the other hand, for the beginning clinicians, the residual rates of nail enamel (non-FS group; FS group) were as follows: labial surface of #12 (25.26±8.38%; 13.03±7.30%), palatal surface of #12 (37.40±18.40%; 31.12±22.27%), distal surface of #13 (7.06±3.84%; 2.38±1.20%), mesial surface of #14 (0.15±0.15%; 13.98±9.78%), and furcation of #46 (31.55±6.13%; 7.14±5.91%). The residual rate in FS group was significantly lower than that of non-FS group in the furcation of #46 ($p<0.05$, n=4). Also for the non-FS group, there was no significant difference in the residual rate of nail enamel between experienced and beginning clinicians. For the experienced clinicians, it was possible to remove nail enamel of root surfaces completely by Nd:YAG laser irradiation using the FS (Fig. 9).

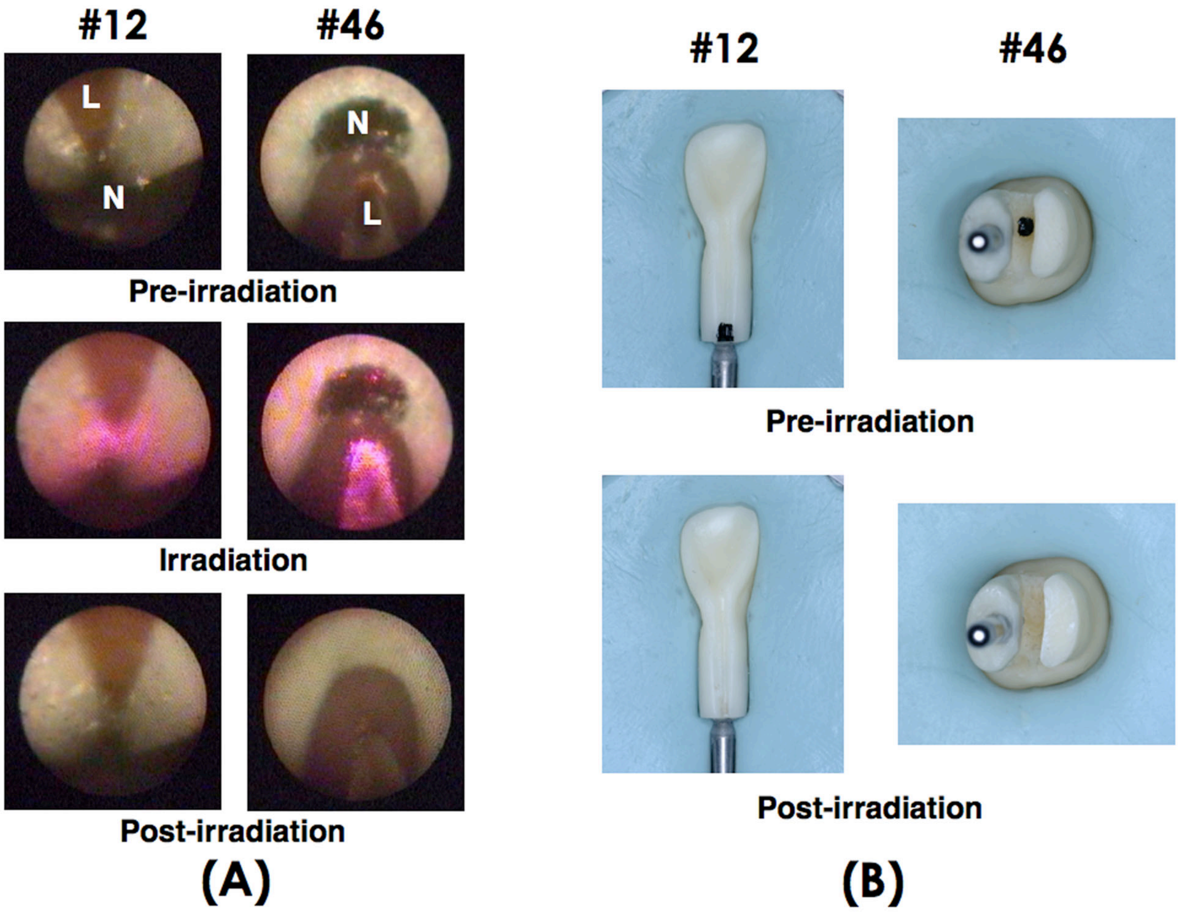

Fig. 9. Observation of the root surfaces by Nd:YAG laser irradiation using the FS
(A) FS findings on the palatal root surface of #12 and the furcation of #46 L: Laser fiber N: Nail enamel
(B) Stereoscopic findings on the palatal root surface of #12 and the furcation of #46

Discussion

Plaque and plaque products are generally known to constitute the primary causative factors in the etiology of periodontal disease.[3-6] Therefore, it is important that plaque and calculus are removed from the surfaces of the affected teeth in periodontal therapy.[7,8] However, there are many reports demonstrating limitations of subgingival treatment, because it is very difficult to adapt periodontal instruments to root surfaces and to use them exactly in deep periodontal pockets.[6,9-12] Waerhaug[6] stated that reformation of junctional epithelium by removing subgingival plaque on extracted human teeth after scaling. As a result, reformation of junctional epithelium occurred in 83% of cases with periodontal pocket measuring less than 3 mm, because subgingival plaque removal was done. But reformation of junctional epithelium could be observed only 11% at a periodontal pocket deeper than 5 mm, because removal of subgingival plaque was difficult. This is in agreement with Rabbani et al.,[9] who evaluated the effectiveness of subgingival SRP related to the depth of pocket. Results of the study demonstrated a high correlation between the percent of residual calculus and probing depth. Pockets less than 3 mm were the easiest sites for SRP, probing depths ranging from 3 to 5 mm were more difficult, and pockets deeper than 5 mm were the most difficult.

Using the FS for subgingival treatment provides direct, real-time visualization and magnification of the subgingival root surface and may provide the clinician with the ability to locate and evaluate the extent and nature of subgingival root deposits. The purpose of this study was to evaluate the usefulness of the FS for subgingival treatment in deep pockets.

In this performed sites, PPD of the original jaw model was more than 5 mm and the residual rate of FS group was lower than that of the non-FS group. Therefore, this result suggested that the application of the FS for subgingival SRP leads to better outcome in comparison with conventional SRP without FS.

But, on the mesial surface of #14, the residual rate of FS group was high. This result is caused by high residual rate of FS group for the beginning clinicians. Although the subgingival root surfaces for the beginning clinicians were observed by the FS, due to unskilled handling, they may have mistaken that the nail enamel had been removed. This result suggested that the beginning clinicians should practice clinically to master the technique of FS.

The dental endoscope (Perioscopy, Dental View, CA, USA) developed by Stambaugh et al.[16-18] is very useful FS system (24x to 46x magnification, 10,000 pixel waveguide fiber, vision field 53 degrees) for periodontal treatments. A fixed, fused fiber optic bundle, less than 1 mm in diameter, was coupled to an active matrix LCD-TFT flat panel video monitor for viewing by the clinician. A bilumen sheath was designed to provide irrigation of the sulcus and a sterile barrier between the patient and the fiber bundle. Standard dental curets and ultrasonic scalers were adapted for the instrumentation aided by the endoscope. It is possible to irrigate with water during treatment. Rinsing with water was essential to obtain a clear view without blood or detached soft and hard tissue obstruction and to differentiate between soft and hard tissue, because small soft tissues move during the flushing process. But this system does not have a working channel. We have been developing an original endscopic system with FS to employ it in clinical dentistry, especially for periodontics and endodontics.[13,14] Medical endoscope technology was modified for the application to the dental environment. Till now, the FS can work with other instruments when sufficient space exists in the lesion area. However, care must be taken not to damage the thin FS with these instruments, which is a difficult task. To overcome this difficulty, the FS was designed with a working channel that not only rinsed with water but also allow the introduction of instruments such as a fine laser fiber and an especial file.

The Nd:YAG laser has a wide spectrum of application in the dental field. Nd:YAG laser has been reported to reduce the amount of subgingival bacterial flora.[19-22] And its application has been investigated for periodontal therapy.[19-26] Optical fiber of Nd:YAG laser is very flexible and its diameter is small. Therefore, it is possible to insert a optical fiber through the working channel. These were the reasons for choosing Nd:YAG laser. The aim of Nd:YAG laser irradiation was to improve the efficiency of periodontal treatment by detoxification of root surface and vaporizing granulation tissues. For several clinical cases, the FS has already been tried with a working channel in which a Nd:YAG laser was inserted for treatments. As a result, good operational views were obtained during the laser irradiation. In this study, the palatal root surfaces of #12 and the furcation of #46, areas posing a challenge to adapt periodontal instruments to the root surfaces, were irradiated with Nd:YAG laser using the FS. And it was possible to remove nail enamel completely by Nd:YAG laser irradiation. This result suggested that Nd:YAG laser irradiation using the FS can improve subgingival periodontal treatment efficiency.

It has been reported that the thermal effects on pulp tissues are dependent on the degree of energy absorption of the lased tissue, and the wavelength and energy densities of the laser used.[27-29] In our study, the laser irradiation was performed under water irrigation and the optical fiber was moved up and down in order to irradiate the root surface as evenly as possible using a FS. Thus, it seems that the energy density and irradiation method in this study may have been safe and was not high enough to cause tissue or pulpal damage.[24,30] However, the Nd:YAG laser irradiation, due to the nature of its wavelength, can penetrate more deeply than other types of laser irradiation. Therefore, further research will be needed to clarify this problem.

In this study, the surgeons consisted of eight dentists, who were divided into four experienced and four beginning clinicians for using a FS. The experienced clinicians have been practiced for more than 10 years, and the experience of using a FS was 7 years or more. However, at present, there are only four experts for using FS in our department, because this system has not been disseminated among the dental profession. So, it is expected that the number of experts may increase in future.

The fiber is placed in a rigid tube of stainless steel with a small diameter to be inserted in various locations. Therefore, if unnecessary pressure is exerted against the hard tissue such as tooth and bone during subgingival treatment, it may bend and fail. Also, the fiber and some parts of these instruments must not be subjected to high temperatures. Hence, these instruments may fail if sterilized using an autoclave. Therefore, the instruments should be sterilized only by chemical agents such as glutaraldehyde or ethylene oxide gas.

In the clinical setting, FS is very useful for observing the periapical tissues and root surfaces, when we perform endodontic and periodontal treatment. It is possible to insert through the fistula, root resorption, amalgam retroseal, perforation, root fracture etc may be observed on the monitor during treatment. On the other hand, in periodontal pockets, the smallest deposit of residual calculus, along with furcations and root anatomy, inflamed soft tissues, perforation, root fracture, subgingival caries, open crown margin and so on may be observed on the monitor. In addition, those recorded image can be used for explanation to patients, as well as for a discussion of diagnosis after examination. This FS system is useful not only for explanation and diagnosis but also for operative procedures.

Furthermore, the FS can be utilized through subgingival pockets, sinus tracts or a minimal intervention without the need for raising surgical flaps to observe the root surface, periapical tissue and foreign materials before, during and after the treatment. The system requires little local anaesthesia, minimal incisions, no flaps elevations and no sutures. As a result, postoperative symptoms can be minimized.

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