The effect of lubricants in removing smear layer on canal enlargement with engine-driven Ni-Ti file

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ABSTRACT

엔진 구동형 니켈 티타늄 파일을 이용한 근관 확대 시 도말층 제거에 대한 윤활제의 영향

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근관계의 완전한 충전을 위해 기계적인 근관 확대 및 화학적인 세척은 필수 불가결하다. 근관내 기구 조작 시 근관벽에는 무기물과 유기물로 구성된 도말층이 형성되는데, 이 층은 서서히 분해되어 충전재 주위에서 미세누출을 야기하고, 세균과 그 부산물이 이동할 수 있는 통로를 제공하기 때문에 제거되어야 한다. 현재 이러한 목적을 위해 다양한 기구들과 세척 용액들이 이용되고 있다.

최근에는 근관확대를 위해 엔진 구동형 니켈-티타늄 파일이 개발되어 임상에서 널리 사용되고 있으며, 이러한 엔진 구동형 파일을 사용할 때는 윤활제의 사용이 필수적이다. 현재 시판되고 있는 윤활제들에는 도말층 제거를 위한 EDTA가 함유되어 있다. 따라서, 본 연구의 목적은 엔진 구동형 니켈-티타늄 파일을 이용해 근관을 확대할 경우 이런 윤활제들의 도말층 제거 효과를 비교 평가하는 것이다. 본 실험에는 75개의 치아가 각각 15개씩 5개의 군으로 분류되어 사용되었다. 대조군은 윤활제를 사용하지 않은 경우이고, 실험 1군에서는 윤활제로 RC-PREP™이, 실험 2군에서는 Glyde™가 각각 사용되었고, 실험 3군은 RC-PREP™을 사용한 후 17% EDTA로 처리하였으며, 실험 4군은 Glyde™를 사용한 후 17% EDTA로 처리하였다. 처리된 시편을 절단한 후 주사전자현미경을 통해 시편의 근관의 중앙부와 치근단 부위를 관찰하여 얻어진 결과는 다음과 같다.

1.대조군과 실험군의 비교시, 대조군에서 더 많은 양의 도말층이 관찰되었고, 이는 통계학적으로 유의성이 있었다 ($P<0.01$).

2. 윤활제의 종류에 따른 비교 시, Glyde™를 사용한 2군에서 RC-PREPTM을 사용한 1군 보다 더 적은 양의 도말층이 관찰되었지만, 이는 통계학적으로 유의성이 없었다.
3. 윤활제 사용과 EDTA 처리에 따른 효과 비교 시, EDTA로 처리한 3, 4군에서 윤활제만을 사용한 1, 2군 보다 더 적은 양의 도말층이 관찰되었으며, 이는 통계학적으로 유의성이 있었다($P<0.01$).
4. 치근 중앙부와 치근단 부위에서의 도말층 제거 효과 비교 시, 1, 2군에서는 치근 중앙부에서 더 적은 양의 도말층이 관찰되었고, 통계학적으로 유의성이 있었다($P<0.01$). 3, 4군에서는 중앙부의 도말층이 더 적었지만, 통계학적으로 유의성이 없었다.

이상으로부터 EDTA가 함유된 윤활제를 함께 사용하면서 엔진구동형 니켈-티타늄 파일로 근관확대 시, 근관벽에 형성된 도말층 제거에 대한 파일의 효능이 상승되었다. 그러나, 윤활제의 도말층 제거 효과는 17% EDTA 용액으로 근관벽을 처리하는 것보다는 낮았다. 따라서, 엔진구동형 니켈-티타늄 파일로 근관확대 시 EDTA가 함유된 윤활제를 함께 사용하는 것이 요구되고, 보다 완벽하게 도말층을 제거하기 위해서는 충전 전에 17% EDTA 용액으로 근관벽을 처리하는 것이 필요하다고 사료된다.

Ⅰ. INTRODUCTION

Endodontic therapy depends primarily on the mechanical removal of calcified materials and on the chemical disinfection and dissolution of organic materials from root canal system[1]. The thorough cleansing and shaping of root canal system are considered as key requirement for endodontic success. Therefore, the importance of mechanical and chemical debridement of root canal has been continuously emphasized.

But, the smear layer is formed by burnishing superficial components of dentinal walls during instrumentation procedure. The smear layer associated with root canal treatment consisted of not only dentine but also remnants of odontoblastic processes, pulp tissue and bacteria[2]. In the infected canal, the smear layer produced by instrumentation should be removed, because bacteria may have invaded dentinal tubules and accessory canals, and smear plugs produced during instrumentation should be removed to facilitate antibacterial effect of intracanal medicaments[3,4]. Also, it has been reported that their removal reduces microbial flora[3,5,6], and enhances the obturation properties of sealing material[7-10]. For these reasons, it may be prudent to create the cleanest dentinal surface possible. Different types of hand or engine-driven instruments and irrigation solutions have been used for instrumentation of root canal.

Different irrigating solutions have been used to remove the smear layer. Although sodium hypochlorite is an irrigant solution used widely in root canal treatment because of its bactericidal activity and ability to dissolve organic materials[11,12], sodium hypochlorite is not effective in removing the smear layer[4]. Acids such as phosphoric, citric, polyacrilic and tannic acid or chelating agents such as EDTA and REDTA have been reported as suitable for removing smear layer[13,14]. Also, other studies have shown that a combination sodium hypochlorite and EDTA removed the smear layer partially[15,16]. Takeda[16] et al. suggested that laser was useful in removing smear layer. Ahmad[17] and Cameron[18] recommend ultrasonic system to remove debri as well as smear layer.

Recently, new engine-driven endodontic instruments made from nickel-titanium have been introduced. They are rotating instruments with variable taper, which have more elastic flexibility, and are more stress resistant compared to stainless steel files. They must be used with lubricants in the root canal because of stress induced on instrumentation procedure. RC-PREP™(premier, Philadelphia, U.S.A.) and Glyde™(Dentsply-Maillefer, Ballaigues, Switzerland) are generally used as lubricants in clinic, and they contain EDTA for root canal conditioning. But, the effect of lubricants on removal of smear layer in the root canal has not been reported.

Thus, the purpose of this study was to evaluate the effect of lubricants, such as RC-PREP™ and Glyde™, in removing smear layer on canal enlargement with engine-driven Ni-Ti file.

Ⅱ. MATERIALS AND METHODS

A. Selection and preparation of teeth

A total of freshly extracted 75 human permanent anterior teeth with single root, single canal and complete apex were used in this study. Any specimen having severe canal curvature, root caries, fracture, previous endodontic treatment and calcification were discarded. Adherent soft tissue on root surface were removed by periodontal currete. To facilitate measurement and instrumentation and to aid in precise length control, the crowns of all teeth were removed at cemento-enamel junction level with tungsten carbide fissure bur in high-speed handpiece.

B. Canal instrumentation

Canal patency was visually established by placing size 15 K-files (Dentsply-Maillefer, Ballaigues, Switzerland) to each canal until it could be seen flush with the external root surface of the apical foramen. This length subtract 1mm established the working length of each canal.

Seventy-five teeth were randomly divided into 5 groups of 15 each, according to lubricants(Table 1).

All canals were prepared using engine-driven Ni-Ti files. The coronal and middle third were shaped with GT™ rotary files(Dentsply-Maillefer, Ballaigues,

Table 1. Grouping according to lubricants.

	lubricants	17% EDTA solution
Control group	No	No
experimental group 1	RC-PREP™	No
experimental group 2	Glyde™	No
experimental group 3	RC-PREP™	Soaked
experimental group 4	Glyde™	Soaked

Switzerland) from .12/20 to .08/20, using crown-down technique. The apical preparation was then completed with PROFILE™ instruments(Dentsply-Maillefer, Ballaigues, Switzerland). Firstly, yellow 0.04 taper PROFILE™ was used at the working length, and then yellow 0.06 taper PROFILE™ was used at the same length. Red 0.04, 0.06 taper, blue 0.04, 0.06 taper and green 0.04, 0.06 taper PROFILE™ were used sequently at the working length. Each PROFILE™ instrument was introduced into the canal at a constant speed of 300rpm with gentle push-pull motion.

The use of each instrument was followed by irrigation with 1mL of 5% NaOCl solution for 10s. The irrigation solution was delivered by an endodontic irrigation probe(Max-i-Probe®, 30gauge/dark blue, Dentsply) placed, as deeply as possible without binding into the middle to apical portion of the canal. The canals were kept flooded with the irrigation agent throughout the instrumentation procedure. The lubricants were dispensed from the tube to a dappen dish and carried to canal on endodontic instruments(GT™ rotary files, PROFILE™). After canal enlargement, specimens of group 3 and 4 were soaked in 17% EDTA solution for 5min. Then, a final flush of 5mL of distilled water was delivered in the same way for 30s. Canals were dried with sterile standardized paper points.

C. SEM examination

To facilitate fracture into two halves, all roots were grooved longitudinally on the buccal and lingual surfaces with a small round diamond bur, avoiding penetration into the canal cavity. Finally, the roots were splited with a small chisel into two halves. Each root section was then dehydrated in graded concentration of alcohol(70, 80, 90, 100%), mounted on an aluminum stub, sputter-coated with gold palladium, and observed with a scanning electron microscope (JSM-840A scanning microscope, JEOL Ltd., Japan).

D. Scoring system

Smear layers were subjected to a standardized semiquantitative evaluation in four grades, according to the classification of Gutmann et al[19,20]. Criteria for the scoring were as followings:

Score of the smear layer: (a) score 1, little or no smear layer; covering less than 25% of the specimen; almost tubules visible and patent(Fig. 3); (b) score 2, little to moderate or patchy amounts of smear layer; covering between 25 and 50% of the specimen; many tubules visible and patent(Fig. 4); (c) score 3, moderate amounts of scattered or aggregated smear layer; covering between 50 and 75% of the specimen; minimal to no tubule visibility or patency(Fig. 5); (d) score 4, heavy smear layering covering over 75% of the specimen; no tubule orifices visible or patent(Fig. 6).

E. Evaluation

Scoring was performed in the middle and apical third of root canal wall. 5 microscopic fields at ×800 were randomly examined and assessed in each third of half-root. Each field was graded from 1 to 4 according to scoring system. The whole root canal wall of each specimen was examined carefully and representative photographs were taken from the middle and apical areas of the wall. The results of scoring measurement were analyzed with Kruskal-Wallis nonparametric analysis followed by Mann-Whitney test to evaluate differences between specific groups at a significance level of $P=0.01$. The Wilcoxon test was used to confirm the significant difference between middle and apical areas within the groups at the $P=0.01$ level.

Ⅲ. RESULTS

A. Control group

The root canal walls of all specimens had been prepared using engine-driven Ni-Ti files without lubricants and had not been treated with 17% EDTA solution.

The root canal walls were covered totally with a thick smear layer. The dentinal tubules were blocked by plugs, and were not visible(Fig. 7, 8). But occasional openings of tubules were observed infrequently(score 3 level).

B. Experimental group 1(RC-PREP™)

The root canal walls showed little or moderate amounts of smear layer. Most of the dentinal tubules were visible and some were covered with thin smear layer(Fig. 9, 10). The wall covered with thick smear layer was in on only one specimen(Fig. 1, 2).

In the middle third, smear layer was thinner than in the apical third. The mean score of smear layer in the middle third were lower than in the apical third, and it was statistically significant ($P<0.01$, Table 2).

Table 2. The scores of smear layer at the middle and apical third in each groups.

Groups (N=15)	Middle	Apical
Control	3.97	3.99
**1	1.95	2.24
**2	1.89	2.23
3	1.12	1.16
4	1.11	1.13

· Mann-Whitney test for difference between specific groups was used.
* shows a significant difference($P<0.01$)
· Wilcoxon test for difference between middle and apical third was used.
** shows a significant difference($P<0.01$)

C. Experimental group 2(Glyde™)

The root canal wall were clean without smear layer or showed moderate amounts of smear layer. The smear layer was thin, and thick smear layer was found at apical third of only one specimen(Fig. 2). The dentinal tubules were visible and open, and some were closed. The surface texture of the root canal walls was generally smooth and even(Fig. 11, 12).

In the middle third, the tubules remained widely open and clean, but in the apical third, this were small and tightly closed. The removal of smear layer was more effective in the middle third than in the apical third, and this was statistically significant ($P<0.01$, Table 2).

D. Experimental group 3(RC-PREP™+17% EDTA solution)

The middle and apical third showed smear layer-free surface respectively. Some tubules were covered with thin smear layer chips(score 2 level) or blocked

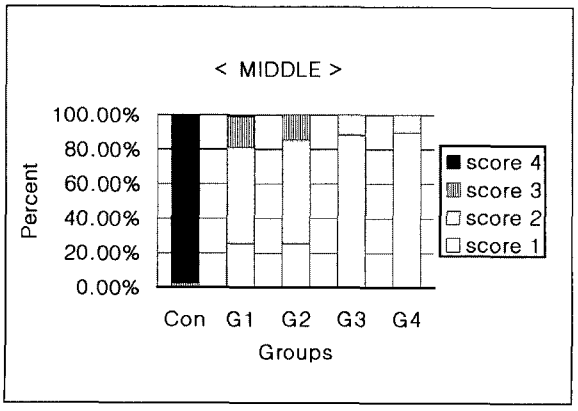

Fig. 1. Total scores in middle third.

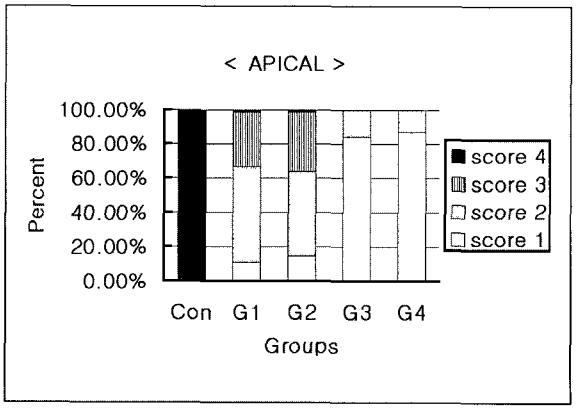

Fig. 2. Total scores in apical third.

by smear plugs. Moderate smear layer was not observed(Fig. 13, 14).

Middle third showed less smear layer than apical third, but there was not significant difference between the middle and apical third(Table 2).

E. Experimental group 4(Glyde™+17% EDTA solution)

The smear layer was nearly removed from the middle third, apical third. The dentinal tubules were cleaned and opened. Some tubules were blocked by smear plugs. Moderate smear layers were not observed(Fig. 15, 16).

Middle third showed less smear layer than apical third, but there was not significant difference between the middle and apical third(Table 2).

The control group showed much greater smear layer than other experimental groups($P<0.01$, Table 2). The experimental groups using lubricants without 17% EDTA solution(group 1, 2) showed significantly greater smear layer than groups using lubricants with 17% EDTA solution(group 3, 4) in the middle and apical third($P<0.01$, Table 2). The group 2 using Glyde™ as lubricants showed less smear layer than group 1 using RC-PREP™, however, there was no statistically significant difference between group 1 and 2(Table 2). Also, group 3 showed less smear layer than group 4, but there was no statistically significant difference between group 3 and 4(Table 2). The group 1 and 2 using lubricants without 17% EDTA solution had statistically significant differences for smear layer removal between the two parts of the root, and middle third showed less smear layer than apical third($P<0.01$, Table 2). Control group, group 3 and 4 showed less smear layer in middle third than apical third, but it was not statistically significant (Table 2).

Figure 1 and 2 show the distribution of smear layer scores in each groups. In control group, score 4 level was predominant absolutely. In smear layer scores of experimental group 1 and 2 prepared using lubricants without 17% EDTA solution, score 2 level occupied the highest percentage, and Score 4 level was examined in two specimens. Score 1 level occu-

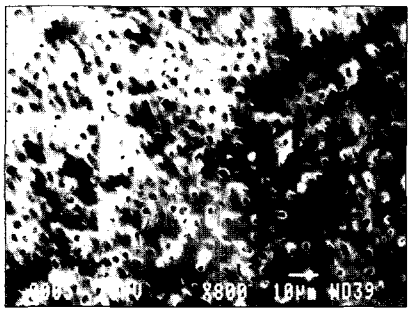

Fig. 3. Score 1 level.

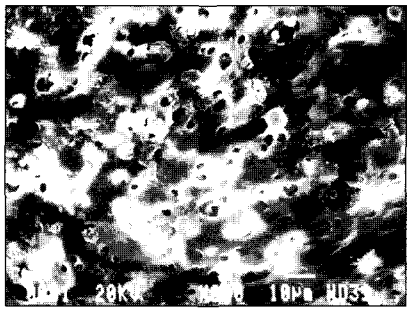

Fig. 4. Score 2 level.

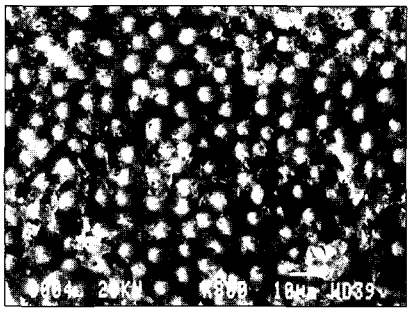

Fig. 5. Score 3 level.

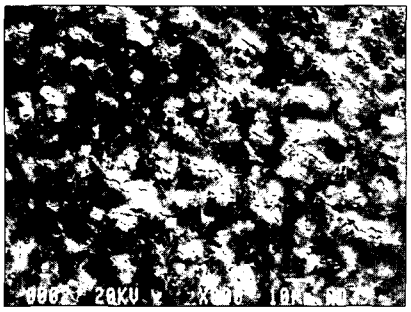

Fig. 6. Sore 4 level.

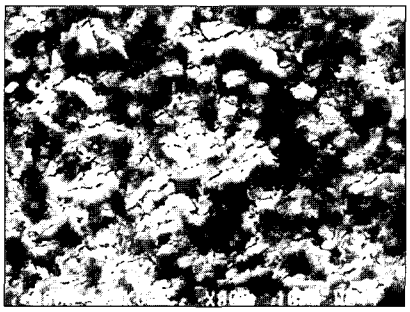

Fig. 7. Specimen in middle third of control group.

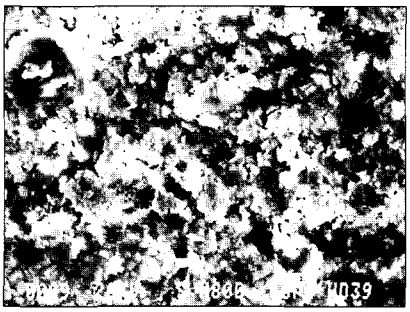

Fig. 8. Specimen in apical third of control group.

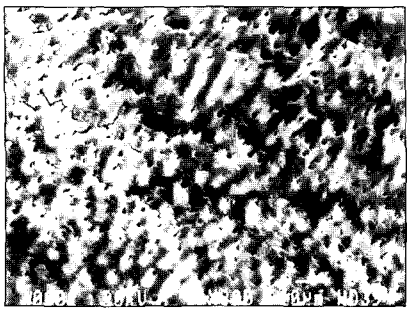

Fig. 9. Specimen in middle third of experimental group 1.

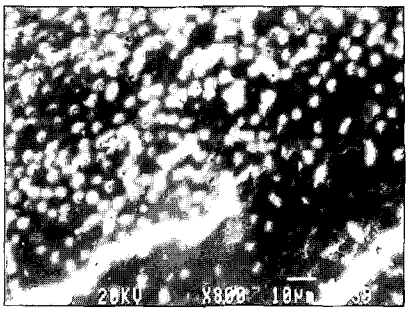

Fig. 10. Specimen in apical third of experimental group 1.

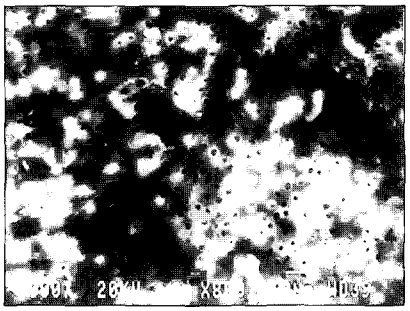

Fig. 11. Specimen in middle third of experimental group 2.

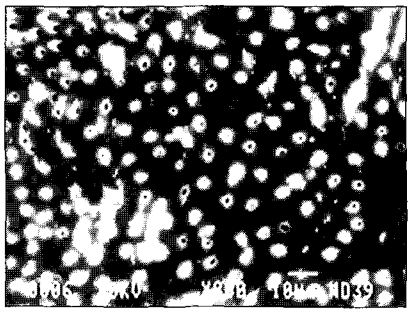

Fig. 12. Specimen in apical third of experimental group 2.

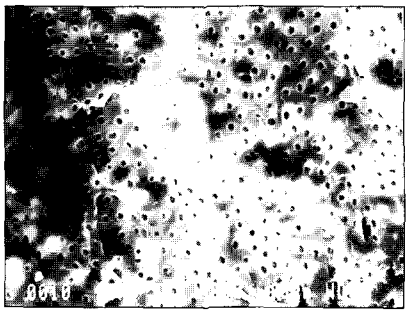

Fig. 13. Specimen in middle third of experimental group 3.

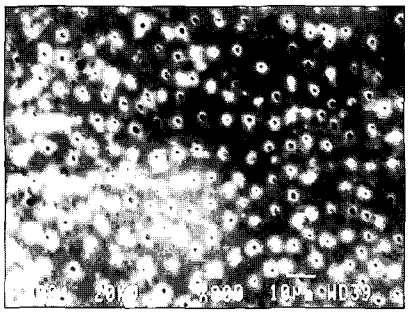

Fig. 14. Specimen in apical third of experimental group 3.

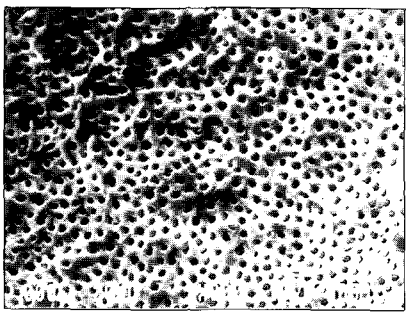

Fig. 15. Specimen in middle third of experimental group 4.

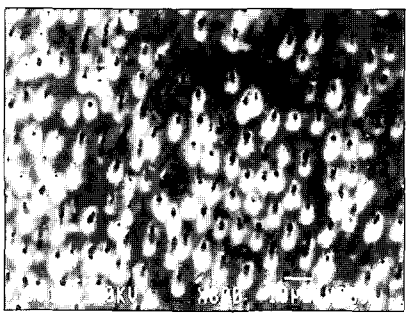

Fig. 16. Specimen in apical third of experimental group 4.

pied the highest percentage in smear layer scores of experimental group 3 and 4 prepared using lubricants with 17% EDTA solution, and score 3 and 4 level was not examined.

Ⅳ. DISCUSSION

A layer of sludge material is always formed on the instrumented root canal walls. This layer is called as smear layer. It has an amorphous, irregular and granular appearance under the scanning electron microscope[21], and is composed of tooth structure and some nonspecific inorganic contaminants. The organic components may consist of reacted coagulated proteins, necrotic or viable pulp tissue, odontoblastic processes, plus saliva, blood cells and microorganism[22].

It has been shown that bacterial byproducts may penetrate through freshly cut dentine[23-25] and that the smear layer itself is permeable even to large mol-

ecules such as albumin[26]. Therefore, this layer is not a strict barrier to bacteria. After degradation of the smear layer by proteolytic enzymes released by certain bacteria[27], a gap will develope between the filling material and the canal wall, permitting the leakage of other bacterial species and their byproducts along the canal walls into dentinal tubules and the periradicular tissue. The smear layer constitutes a negative influence on the sealing ability of obturated canals, since it is porous and weakly adherent interface between the obturation material and the dentine wall[8,9].

When the root canal becomes heavily infected, bacteria may be found deep in the dentinal tubules[28]. Even after chemomechanical instrumentation of the root canal, some bacteria still remain in the canal and dentinal tubules[3]. For this reason, chemomechanical cleansing is often supported by the use of disinfectants.

Different solution and techniques have been used to remove the smear layer. Even though NaOCl has a high solvent action, it cannot remove this layer[11,29,30,31]. Sequential use of NaOCl and EDTA solutions has been recommended to remove the endodontic smear layer[12].

During preparation, insufficient removal of smear layer material and debris induce stresses on the cutting segment of endodontic instruments[32]. Their removal depends not only on irrigation method but also on the endodontic instrument, the way the instrument is used and the method of preparation[32]. Wesselink[33] et al. have compared the cleansing efficacy of crown-down pressureless, a balanced-forced and a traditional step-back technique. Several studies have shown the inability of conventional or modified K-type files to remove smear layer material and debris when using step-back technique and NaOCl as irrigants. Recently, some studies on cleansing efficacy of engine-driven Ni-Ti files were reported. Bertrand[32] et al. reported that the Quantec™ rotary system produced cleaner canal wall than conventional manual instrumentation in study determining of ability of the Quantec™ Series 2000 rotary Ni-Ti endodontic system to remove dentinal smear layer and debris produced during canal preparation, but Bechelli[19] et al suggested that the choice between hand and LightSpeed™ instrumentation should be based on factors other than the amount of root canal debridement, which does not vary significantly according to the instruments used. These studies on cleansing efficacy of engine-driven Ni-Ti files did not referred to use of lubricants. But, engine-driven Ni-Ti file must be used with lubricants in the root canal, because of stress induced on instrumentation procedure. The marketed products such as RC-PREP™, Glyde™ was applied into the root canal as lubricants in this study. RC-PREP™ contains Ethylenediaminetetraacetic acid(EDTA) and urea peroxide in a water soluble glycol base. Glyde™ is combination of Ethylenediaminetetraacetic acid(EDTA) and carbamide peroxide in a water soluble base. RC-PREP™ and Glyde™ have been used for the both purposes of lubrication and root canal conditioning. In this study, the specimens of control group prepared without lubricants showed heavy smear layer, and in only one specimen of control group, smear free surface of score 3 level was examined. Score 4 level occupied the highest percentage in smear layer scores of control group. But, in the specimens of experiment group 1 and 2 prepared with lubricants, smear layer was very thin, dentinal tubules were visible, and little heavy smear layer was examined. Score 2 level occupied the highest percentage in smear layer scores of experimental group 1 and 2. It is seemed that lubricants containing EDTA can induce decalcification of root canal wall and dissolve the smear layer during canal preparation. The mean value of smear layer scores in experimental group 1 and 2 was 2.08, therefore, lubricants seemed to remove smear layer of about 50% and above. For these results, in study concerning cleansing efficacy of engine-driven Ni-Ti file, the effect of lubricant on removal of smear layer during canal preparation should be considered.

The use of RC-PREP™ compared with Glyde™ was associated with lesser degree of smear layer removal in middle third and apical third on the root canal wall, but this difference was not statistically significant.

Looking at different regions of the canal, residual smear layer was more evident in apical third than middle third. Only in experimental group 1 and 2 prepared using lubricants without 17% EDTA solu-

tion, however, this difference was significant. The majority of studies concerning cleansing efficacy have concluded that smear layer was always more abundant in apical third[19,32,34-37].

The experimental group 3 and 4 prepared using lubricants with 17% EDTA solution showed smear layer-free surface throughout the whole root canal wall. The mean value of smear layer scores in experimental group 3 and 4 was 1.13, therefore, smear layer of about 75% and above seemed to be removed. There were highly significant statistical differences between the experimental groups prepared using lubricants with 17% EDTA solution and the experimental groups prepared using lubricants without 17% EDTA solution. The results showed that use of lubricants with 17% EDTA solution more effective in removing smear layer than use of only lubricants.

Ⅴ. CONCLUSION

This study evaluated the effect of lubricants in removing the smear layer on canal enlargement with engine-driven Ni-Ti files. In this study, seventy-five teeth were randomly divided into 5 groups of 15 each, according to the lubricants used on each group. The teeth of the control group were prepared without the lubricants . In experimental group 1, the teeth were prepared with RC-PREP™ as a lubricant, and in experimental group 2, the teeth were prepared with Glyde™. The specimens of groups 3 and 4 were prepared with same lubricants, respectively as groups 1 and 2, and then soaked in 17% EDTA solution. The middle third and apical third of the root canal wall were examined using a scanning electron microscope. Results obtained from the study above were as follows:

1. The control group showed a greater smear layer than other experimental groups, and it was statistically significant($p<0.01$).
2. Group 2 using Glyde™ as a lubricant showed less of a smear layer than group 1 using RC-PREP™ as a lubricant, but it was not statistically significant.
3. Groups 3 and 4 soaked in 17% EDTA solution showed less of a smear layer than group 1 and 2 using lubricants without EDTA, and it was statistically significant($p<0.01$).
4. The middle third showed less of a smear layer than apical third in groups 1 and 2 and the difference was statistically significant($p<0.01$). In group 3 and 4, the middle third showed less of a smear layer than apical third, but it was not statistically significant.

When the engine-driven Ni-Ti file was used with lubricants containing EDTA, the efficiency of the engine-driven Ni-Ti file on removing the smear layer formed in root canal wall was improved. But, the efficiency of lubricants in removing the smear layer was lower than the additional use of 17% EDTA solution. Therefore, engine-driven Ni-Ti files must be used in the root canal with lubricants containing EDTA, and for complete removal of the smear layer, the root canal wall should be cleaned with 17% EDTA solution before root canal obturation.

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