2014년 2월

석사학위논문

A comparison of cleaning efficiency of various irrigation methods

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여러 가지 근관 세척 방법에 따른 세척 효율의 비교

2014년 2월 25일

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이 논문을 치의학 석사학위신청 논문으로 제출함.

2013년 10월

조선대학교 대학원

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박성환의 박사학위논문을 인준함.

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2013년 11월

조선대학교 대학원

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본 연구에서는 음파 근관세척 기구인 EndoActivator와 초음파 근관세척 기구인 CK file의 근관 내 도말층 제거 능력을 평가하고 더 나아가 기존의 수동 세척법과 비교하여 차이가 있는지 알아보고자 하였다. 근첨이 완성되고, 근관의 만곡이 없는 사람의 단근치 60개를 준비하였다. 실험과정의 표준화를 위해 치관부를 절단하고 #25, #40 WaveOne^{TM} Ni-Ti file, #50 K file을 순차적으로 사용하여 근관확대를 시행하였으며 각 확대 과정 후에는 1 ml의 2.5% NaOCl로 세척하였다. 근관확대 완료 후, 3개의 군으로 나누어 최종세척을 시행하였다. 첫 번째 그룹은 기존의 manual needle irrigation으로 근관세척을 시행하는 대조군으로 설정하였고, 두 번째 그룹은 EndoActivator와 전용 #25 polymer tip을 사용하여 세척액이 채워진 근관 내에서 음파 근관 세척법을 적용하였고, 세 번째 그룹은 #25 CK file로 세척액이 채워진 근관 내에서 초음파 근관 세척법을 적용하였다. 최종세척과정에는 5 ml의 17% EDTA와 5 ml의 2.5% NaOCl이 사용되었다. 근관 건조 후 치근을 절단하여 노출된 근관의 내면을 주사전자현미경으로 관찰하였다. 독립된 두 명의 조사자가 현미경 하에서 얻은 이미지를 통해 근관 내 상아질 벽에서의 도말층 제거 정도를 평가하였다. 분석 결과, 치근단 3 mm 부위에서 EndoActivator와 CK file을 사용한 두 실험군 모두 대조군에 비해 유의적으로 높은 도말층 제거 결과를 보였으며 두 실험군 간에는 유의적인 차이를 보이지 않았다.

I. Introduction

The ultimate objectives of endodontic treatment is to eliminate the microorganisms and prevent the recontamination in root canal system.[1] To achieve these objectives, mechanical and chemical preparation methods of root canal system are essential procedures.[2]

The preparation of the root canal is performed almost by hand and rotary instrumentation techniques. The aim of this instrumentation is to shape the canal, remove infected dentin, and facilitate satisfactory delivery of irrigants to the apical anatomy, while maintaining the patency of the entire canal system and preserving the integrity of the tooth.[3] Several new kinds of nickel-titanium(Ni-Ti) file systems have been introduced. One of these systems, WaveOne™ (Dentsply Mailefer, Switzerland) is designed to prepare and clean the root canals completely with only one instrument.[4]

During root canal instrumentation, a layer of organic and inorganic material called the smear layer could be formed. The smear layer is potentially infected, and its removal allows effective penetration of intracanal medications into the dentinal tubules and a better interface between the filling material and the root canal walls.[2,5] At the apical third portion of root canal, cleanliness is critical due to the limited space, low permeability[6] and complex anatomical configuration.[7] For these reasons, a variety of chemical agents have been used conventionally as irrigating agents such as sodium hypochlorite (NaOCl)[10] and 17% Ethylenediaminetetraacetic acid (EDTA).[11] However, conventional manual irrigation method is not effective in the apical area of the root canal.[12] Recently, emphasis has been devoted to hydrodynamic irrigation methods, consisting of sonic or ultrasonic fluid activation in pre-shaped canals. These systems promote fluid circulation through vibration.[9,10,12,13]

The EndoActivator (Dentsply, Tulsa, OK) is sonic device and it has been shown to safely clean the canal system, including lateral canals, fins, and isthmus, by activating the irrigants with a flexible, noncutting and 3 different sized(#15, #25, #35) polymer tip.[7,8] Mechanical oscillations are produced mainly at the tip of the

activator with a frequency ranging from 1 to 10 kHz. The CK file (B&L Biotech, Korea) is a relatively new device on the market. It is connected to hand piece of ultrasound generator via 90° or 120° file holder and generate acoustic micro-streaming of the irrigants by using ultrasonic energy. This device is compatible with both EMS system and SATELEC system, and the tips are composed of 4 different size(#20, #25, #30, #35). According to the manufacturer's recommendation, 10% of maximum energy of engine is suitable for efficient cleaning of the root canal, and proper acting depth is 3 mm subtracting from working length of the canal.

The objective of this study was to compare the effectiveness of the EndoActivator and CK file on removing the smear layer after mechanical instrumentation and irrigation with EDTA and NaOCl.

Ⅱ. Materials and Methods

1. Sample Selection

Sixty intact, single-rooted and straight human teeth with mature apex were collected for this study. All teeth were radiographed in a bucco-lingual and a mesio-distal direction to confirm single, straight canal morphology. The teeth were stored in 0.9% physiologic saline at 4 ℃ after extraction.

2. Mechanical preparation of root canals

All teeth were decoronated at the cementoenamel junction with a diamond disk for simple procedures. After decoronation, lengths of the roots were measured by passively placing a #10 K-file in the canal until the tip of the instrument visibly penetrated. The actual working length was calculated by subtracting 1 mm from this measurement.[15] The apices were sealed with melted sticky wax to close the apical foramens in order to simulate in vivo condition which is not allowed escaping irrigants through the apex of each roots.[16,17] The teeth were instrumented with #25 WaveOne^{TM} file to the working length first, and then, irrigated 1 ml of 2.5% NaOCl by manual irrigation method. The irrigant was delivered in a 10 ml syringe, with a 27-gauge side-vented needle. Secondly, #40 WaveOne^{TM} file was used to the working length and finally #50 K-file was used to expand and confirm the foramen diameter. Consequently, apical size was standardized in #50. After completion of instrumentation, the teeth were randomly divided into three groups with 20 teeth in each.

3. Final irrigation procedures

(1) Group 1 : Manual needle irrigation group

The canals were irrigated and maintained with 2.5 ml of 17% EDTA for 1 minute with no activation. And then, the canals were irrigated again with 2.5 ml of 17% EDTA. After aspiration, the canals were irrigated and maintained with 2.5 ml of 2.5% NaOCl for 30 seconds with no activation, followed by irrigating with 2.5

ml of 2.5% NaOCl.

(2) Group 2 : Activated irrigation with EndoActivator (EA)

The canals were irrigated with 2.5 ml of 17% EDTA and sonically activated for 1 minute by EndoActivator with #25 sized polymer tip. And then, the canals were irrigated again with 2.5 ml of 17% EDTA. After aspiration, the canals were irrigated with 2.5 ml of 2.5% NaOCl and sonically activated for 30 seconds by EndoActivator with #25 sized polymer tip, followed by irrigating with 2.5 ml of 2.5% NaOCl.

(3) Group 3 : Activated irrigation with CK file (CK)

The irrigation was carried out with a simiar protocol as group 2 using CK file. The canals were irrigated with 2.5 ml of 17% EDTA and ultrasonically activated for 1 minute by CK file with #25 sized tip. And then, the canals were irrigated again with 2.5 ml of 17% EDTA. After aspiration, the canals were irrigated with 2.5 ml of 2.5% NaOCl and ultrasonically activated for 30 seconds by CK file with #25 sized tip, followed by irrigating with 2.5 ml of 2.5% NaOCl.

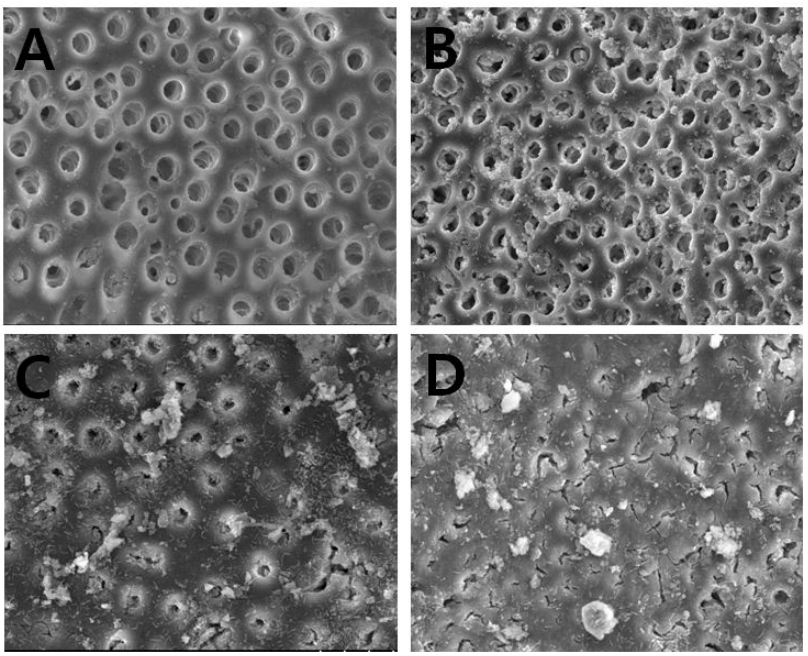
4. Sectioning of the roots and preparation for SEM

After mechanical and chemical preparation, all roots were dried with paper point. And then, to prevent invasion of debris into the canal, #50 Gutta-percha cones were fitted. To get precise samples for SEM, several sectioning procedure was accomplished. Firstly, longitudinal grooves were made with a diamond disk on buccal and lingual surface of the root. Secondly, horizontal groove was made on 3 mm from apex of the roots. Finally, the root were split with chisel to get 3 mm sized cross-sectioned samples of apex area, and the remnants were discarded.[18] Each sample was dehydrated and view with a SEM (S4700, Hitachi, Japan).

5. SEM evaluation and statistical analysis

All samples were viewed at low magnification in order to observe overall image. The micrographs of the most representative three areas of each samples were

obtained at a ×1000 magnification. Total 180 micrographs were scored blindly by two independent evaluators to measure the amount of smear layer using a 4-step scale as follows; (0) all tubules visible, (1) more than 50% of tubules visible, (2) less than 50% of tubules visible, and (3) no tubules visible (Figure 1).[15] The data were analyzed by means of the Kruskal-Wallis test and Mann-Whitney test. The level of significance was set at $p < 0.05$.



(a) Score 0
(b) Score 1
(c) Score 2
(d) Score 3

Figure 1. SEM images and a scale used to evaluate sample cleanliness.

Ⅲ. Results

The representative micrographs of each groups are presented in Figure 2 and the results for smear layer removal in the apical 3 mm are summarized in Table 1 and Figure 3.

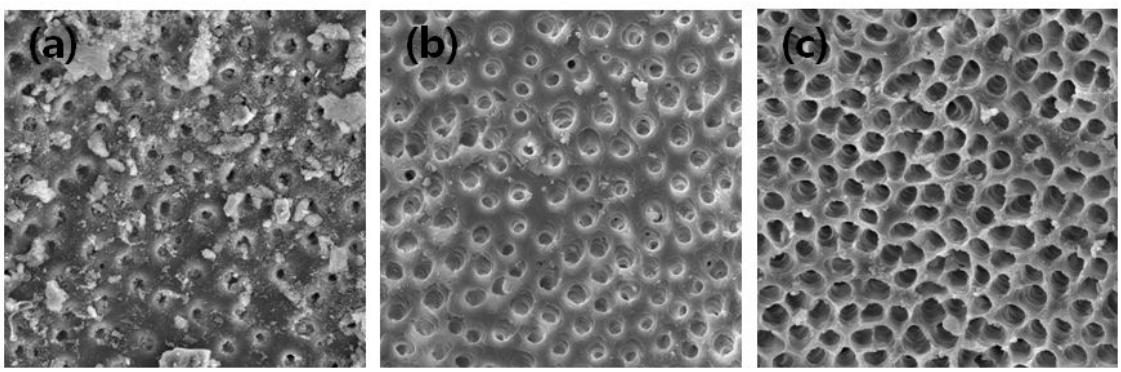


Figure 2. The representative micrographs of each groups. (a) Group 1 : Manual needle irrigation. (b) Group 2 : Activated irrigation with EndoActivator. (c) Group 3 : Activated irrigation with CK file.

Table 1. Smear layer scores

Group	No.	Mean ± SD
Group 1	20	1.80 ± 0.616
Group 2 (EA)	20	1.10 ± 0.968
Group 3 (CK)	20	0.95 ± 0.759

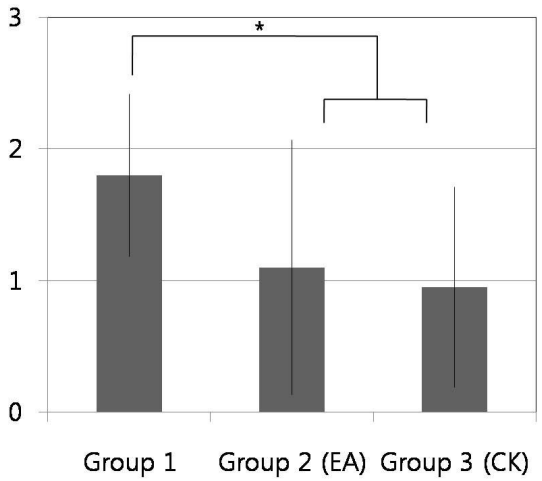


Figure 3. Bar diagrammes showing mean smear layer score.
*: $p < 0.05$

The results showed that the groups treated with EndoActivator (Group 2) and CK file (Group 3) had significantly effective in removing smear layer than group treated with manual needle irrigation (Group 1) ($p < 0.05$). However, there was no significant difference between group 2 and group 3.

IV. Discussion

Irrigation of the root canal system is a fundamental part of endodontic treatment. The efficacy of irrigation depends on how effectively it can remove debris in canals.[19] And also, the infiltration of the irrigant within the apical third of root canals depends on their complex anatomy and removal of the smear layer from these complex canal system.

Conventionally, manual irrigation method has been used in chemical preparation within root canal. However, recently, several studies revealed the imperfection of manual irrigation method in removing smear layer. Ram[20] reported that during manual irrigation, the irrigating solution passes only 1 mm deeper than the tip of the needle. Chow[21] reported that, by manual irrigation, though adequate time and volume consuming, there was a limitation in contentable removal of debris in root canals.

Activation of NaOCl and EDTA with a sonic or ultrasonic devices during chemical preparation appeared to improve the smear layer removal and cleaning capability of the irrigants.[22] Comparing the effectiveness of these two different activating device is still a controversial subject.[23] Rodig et al[24] found no difference in smear layer removal between the EndoActivator and ultrasonic activating method. Also, Jensen et al[25] reported that when the acting time of devices is increased, there was no significant difference between sonic and ultrasonic activation method at cleaning root canals. However, Sabin et al[26], Stamos et al[27] reported that there was a correlation between acoustic streaming velocity and frequency of device, and therethough, they claimed that ultrasonic activating system is more effective in removing smear layer than sonic activating system.

In the present study, the results showed that in group 2 and 3, the removal of smear layer was significantly greater than group 1. Between group 2 and group 3, group 3 (CK file) showed slightly better outcome than group 2 (EndoActivator) but, there was no significant difference.

Despite the efforts to standardize the root canal system, wide variation of each

canal morphology was still difficult variable to control. The original size of a canal may influence the amount of producing smear layer, and sequentially it could effect the debridement efficacy of the instrument.

In this study, WaveOne^{TM} Ni-Ti file was used in mechanical preparing instrument of the canals. In comparison with other mechanical preparing instrument, the number of instrument is decreased up to one or two, and thereby, necessary time for preparation is decreased. Simultaneously, the time available for irrigation and chemical debridement of the root canal system is also reduced. In this regard, changing mechanical preparation system may affect irrigation efficiency and result of study.

A various analyzing methods have been described to evaluate the cleanliness of root canal system. In this study, the cleanliness of root canal was evaluated by two independent evaluator and they scored SEM images. At this point, problems of quantifyng the cleanliness of root canal system could be occur. To obtain objectivity of results, further studies are required to quantify the level of cleanliness of root canal system.

V. Conclusion

In conclusion, both activating devices, EndoActivator and CK file were more effective in removing smear layer from the apical 3 mm of the root canal than manual irrigation method. With evidence of this results, activating irrigation methods using sonic or ultrasonic devices should be clinically considered for obtaining ideal cleanliness of apical area.

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