

COMPARISON OF ULTRASONIC AND SONIC ROOT END PREPARATIONS USING ANAEROBIC BACTERIAL LEAKAGE MODEL

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국문초록

ANAEROBIC BACTERIAL LEAKAGE MODEL을 이용한 음파와 초음파 치근단 와동 형성 기구에 대한 비교

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최근 치근단 와동 형성 시 초음파 또는 음파 기구를 이용하는 것이 보편화 되어 있고 여러 측면에서 평가되어져 왔다. 본 연구의 목적은 혐기성 세균을 이용한 미세 누출 모델을 이용하여 초음파와 음파 기구를 사용, 치근단 와동 형성을 하였을 때 두 기구의 사용이 충전된 치근단 와동의 미세 누출에 미치는 영향을 비교 평가하는 것이다.

48개의 단근치의 근관을 crown-down 방법을 이용 Profile로 .06 black까지 근관 성형을 시행하고 수직 가압법을 사용하여 gutta-percha와 AH26 sealer를 이용하여 근관 충전을 시행하였다. 각 충전된 시편의 치근단 3mm를 절제하였다.

각 시편은 이미로 4군으로 나누었으며 1군에서는 치근단 와동을 초음파 기구로 형성하였고 2군에서는 음파 기구로 형성하였다. 3군은 음성대조군으로 4군은 양성대조군으로 분류하였다. 형성된 치근단 와동은 공기 분사침을 이용하여 건조 후 super EBA 시멘트로 충전하였으며 Anaerobic chamber에서 Fusobacterium nucleatum (VPI 10197)을 사용한 혐기성 세균 미세누출 모델을 이용하여 30일간 미세 누출을 관찰한 결과, 초음파 기구를 사용한 군에서는 80%에서 음파 기구를 사용한 군에서는 75%에서 미세누출이 나타났으나 통계적으로 유의성 있는 차이는 보이지 않았다.

주요어 : 미세 누출, 치근단 와동 형성, 초음파 기구, 음파 기구, anaerobic bacterial leakage model

I . Introduction

The ultimate purpose of periradicular surgery is regeneration of the periapical tissues to a healthy state. The hermetic sealing of any potentially noxious agent within the physical confines of the root should prevent reinfection around the neapex¹⁾. To obtain this goal, root end preparation must achieve clean axial walls, sufficient depth and retentiveness²⁾. For many years special small burs driven by a microhandpiece were used for root-end preparation. The conventional microhandpiece poses several problems to the surgeon, such as (a)

difficult access to the apex; (b) cavity preparation not parallel to the canal; (c) risk of lingual perforation; (d) insufficient depth of the root-end filling³⁾.

Recently, sonic and ultrasonic instruments have been introduced for the purpose of preparing apical cavities and they solved some of these problems. Ultrasonic instruments have been found to be capable of effective dentine cutting⁴⁾ and to be efficient at removing superficial debris within the root-end cavity⁵⁾. The cavities produced by ultrasonic instruments have been claimed to be more parallel, deeper, more retentive and follow the

direction of the canal⁶⁾. Sonic instruments also have been advocated in that they provide an ideal tool for obtaining an appropriate depth and shape of the retrocavity⁷⁾. There were few experimental and clinical studies comparing sonic and ultrasonic root-end instrumentation. The purpose of this study was to compare ultrasonic and sonic root end preparation using anaerobic bacterial leakage model.

II. MATERIALS & METHODS

Forty-eight extracted human teeth, with fully developed apices, straight and single root canals were used in this study. Teeth with large, grossly carious lesions approaching the pulp were excluded to minimize the possibility of preoperative bacterial contamination of the root canal. All teeth were stored in 0.05% NaOCl.

The root canal was prepared to a .06 #40 apical canal size with Profile (Profile, Dentsply Maillefer, Ballaigues, Switzerland) using crown down technique. All instrumentation was accompanied by copious irrigation with 2.5% NaOCl. The root canals were obturated with GP cone and AH26 sealer using warm vertical condensation technique. After obturation, the teeth were stored in distilled water at room temperature until used. The apical 3-4mm of each root was resected under copious water spray using a straight fissure diamond bur, in a high-speed handpiece perpendicular to the long axis of the tooth. These teeth were divided randomly into root-end cavity preparations using either ultrasonic tips (n=20) or sonic tips (n=20).

In the ultrasonic preparation group, a root end cavity was prepared to a depth of 3mm using an ultrasonic tip (KiS™ Microsurgical instruments, Swiss Machining Inc., San Diego, USA)⁸⁾. KiS instruments are slightly longer than other microsurgical instruments for better access. They have unique shaft and tip angles. The shoulder present between the active portion and the shank is 3mm from the tip of the instrument and was used as a guide to the depth of the root-end cavity.

In the sonic preparation group, the KaVo

SONICretro tips (SONICflex retro, KaVo Co., Biberach, Germany) were used. The tips have a diamond coating 3-4mm long. The retrotips are available in two shapes. After retrocavity preparation to a depth of 3mm with flameform, T-form was used to form undercut^{3,7)}.

The root-end cavities were judged to be completed when the gutta-percha and root canal sealer were not present on the wall of the cavity and the cavity depth was at least 3mm. The Gutta-percha at the base of the cavity was condensed with a small plugger. The root-end cavity was dried with a stream of air. Freshly mixed super EBA cement was placed into the root-end cavity and packed until the cavity was full. The root-end filling was allowed to set and was then smoothed using an ultrafine diamond bur in a high-speed handpiece with water coolant. Each root was stored at room temperature ($21 \pm 2^\circ \text{C}$) and 100% relative humidity for 24 h to allow complete setting of the EBA cement. Afterwards the gutta-percha was removed from each canal as completely as possible by H-file and Profile. The state of retrofilling and gutta-percha removal was radiographically evaluated.

The outer root surface was sealed with two coats of nail varnish except the resected surface of the apical end. The negative controls were similarly sealed with two coats of nail varnish including the resected surface apically.

Classification of groups according to retrograde preparation is as follows:

- Group 1 (n=20): retrograde preparation using ultrasonic tip
- Group 2 (n=20): retrograde preparation using sonic tip
- Group 3 (negative control, n=4): sealed with two coats of nail varnish including the resected apical root end
- Group 4 (positive control, n=4): no root end filling

Bacterial leakage model designed by Baumgartner and Bae et al.⁹⁾ was used. A dual chamber anaerobic bacterial model was assembled using a 5 ml irrigation syringe and tooth as the upper chamber, and a 20 ml scintillation vial as

Table 1. Criteria for leakage scores

Score	Time(days) for leakage to occur
0	No leakage at 30days
1	22-30
2	15-21
3	8-14
4	1-7

the lower chamber. The syringe was secured via a hole drilled through the cap of a 20 ml scintillation vial and luted in place with polyvinyl chloride glue and cyanoacrylate cement. The tooth was attached with polyvinyl chloride glue to the tip of the syringe to complete the upper chamber and the joint sealed with two coats of nail varnish. A plastic cap of a 5 ml vial was used to cover the tube opening of the upper chamber. All specimens were then sterilized using ethylene oxide gas.

The vials were placed in the anaerobic chamber for 48 h to eliminate any oxygen in the system and to check for sterility of the system. Brain heart infusion broth (bpBHI) supplemented with yeast extract (5 g/L), hemin (5 mg/L), menadione (10 mg/L), and 20 µg/L bromcresol purple was aseptically placed into the lower chamber so that the root ends were completely immersed in the BHI broth. Bromcresol purple is a chromogenic indicator that changes color from purple at pH 6.8 and above to yellow as the pH decreases to 5.2 in the presence of acidic bacterial by-products. One hundred microliters of bpBHI broth turbid with *Fusobacterium nucleatum* (VPI 10197) was pipetted into the upper chamber syringe reservoirs along with 3 ml of sterile broth. The vials were incubated in the anaerobic chamber at 37°C and observed for turbidity and/or color change of the broth, indicating bacterial growth from penetration of bacteria past the root end filling.

III. RESULTS

All the teeth in the positive control group exhibited bacterial leakage within 48 h, whilst the api-

Table 2. Leakage score of the groups

Group	Leakage scores					Percentage of specimens showing leakage
	0	1	2	3	4	
Ultrasonic (n=20)	4	1	4	5	6	80
Sonic (n=20)	5	5	1	5	4	75
Negative control	4	0	0	0	0	0
Positive control	0	0	0	0	4	100

cal chamber of teeth in the negative control group remained uncontaminated throughout the test period. Eighty percent (n=16) of the ultrasonically prepared group showed leakage after 30 days, while seventy-five percents (n=15) of the sonically prepared group showed leakage after the same time. Analysis of the data (Mann-Whitney Rank Sum Test) yielded no statistically significant differences in leakage between the groups (p>0.05).

The criteria for leakage scores and the number of teeth in which leakage occurred is shown in Table 1 and Table 2.

IV. DISCUSSION

Since the introduction of ultrasonic and sonic instruments, a number of experimental and clinical studies have investigated different aspects of their application in periradicular surgery.

Wuchenich et al.⁶⁾ compared ultrasonic and bur root-end cavity preparations with regard to retention, cleanliness and root canal parallelism. The ultrasonic cavities produced more parallel walls and deeper depths for retention. Ultrasonic tips followed the direction of the canals more closely than those prepared by burs. The dentinal walls of root end cavities prepared by the ultrasonic tips revealed many open dentinal tubules and a minimal debris layer. Gutmann et al.⁵⁾ determined the degree of superficial debris and smear layer present on the dentinal walls of root-end cavity preparation. While root-end preparation with a bur created a heavy smear layer at all levels of the preparation, this layer was partially removed during ultrasonic preparation in the apical two-thirds. Mehlhaff et al.¹⁰⁾ also compared ultrasonic

and high-speed-bur root-end preparations. The ultrasonic tip produced a deeper root-end preparation. Less bevel of the root-end is required to facilitate preparation. The ultrasonic preparation also followed the direction of the canal space. Chailertvanitkul et al.¹¹⁾ compared coronal leakage of a super EBA material used as a root-end filling after root-end cavity preparation with either an ultrasonic instrument or a bur using two species of microorganisms. This study was the only one to demonstrate significantly less coronal leakage of root-end fillings following ultrasonic root-end preparation compared to bur preparation. However, Saunder et al.¹²⁾ have shown that the ultrasonic technique produced significantly more cracks at the root end than the conventional bur technique.

Lloyd et al.¹³⁾ compared root-end cavities prepared with sonic Retro-prep tips with those created by burs in a conventional handpiece. Sonic instrumentation of root-end cavities produced significantly more marginal chipping.

While there have been many studies comparing ultrasonic and bur root-end instrumentation, there have been a few study comparing sonic and bur root-end instrumentation. In addition, comparison of sonic and ultrasonic root-end instrumentation has not been investigated. For that reason, our study compared ultrasonic and sonic instrument using bacterial leakage model.

The most popular method to evaluate the leakage was linear measurement of tracer (dye or radioisotope). But the bacterial leakage model used in the present study may be more accurate in clinical situations than radioisotope and dye. Anaerobes predominate in infections of endodontic origin and *F. nucleatum* used in our bacterial leakage model was one of the most commonly isolated microbes in the 29 periapical lesions with no detectable communication with the oral cavity¹⁴⁾. Bacterial leakage model used in our study was a dual chamber anaerobic bacterial model designed by Baumgartner and Bae et al.⁹⁾. The two chamber method allows observations at selected time intervals¹⁵⁾.

But bacterial leakage model has its limitations.

In our study only one strain of bacteria was used as compared with the mixed flora found *in vivo*. The model was static and there was no interaction with body fluids such as blood, lymph, saliva and pus¹⁶⁾.

In this study, eighty percent (n=16) of the ultrasonically prepared group showed leakage after 30 days, while seventy-five percent (n=15) of the sonically prepared group showed leakage after the same time. Root end cavities prepared with sonic device demonstrated less apical leakage than with ultrasonic device but there was no statistically significant difference in leakage between ultrasonic group and sonic group. The result obtained in this study shows that any instrument of the retrotips will be satisfactory if the basic principles of the retro-preparation are kept, and the use of a root end preparation technique with sonic device can be advocated as well as with ultrasonic device.

It is possible that removal of GP cone affected the sealing ability of Super EBA. That may be why the percentage of leakage was generally high. But analysis of the results was not affected because all experimental groups were under the same condition. Canal obturation without sealer will be needed in the next study so that the gutta-percha can be more easily removed after retro-filling.

Additional study using SEM analysis seems to be necessary to compare the cavities prepared by ultrasonic instruments with the cavities prepared by sonic instruments.

V. Conclusion

The purpose of this study was to compare ultrasonic with sonic root end preparations using anaerobic bacterial leakage model. Forty-eight single rooted teeth were instrumented with Profile using crown down technique to .06 black and obturated with GP cone and AH26 root canal sealer using vertical condensation technique. The apical 3mm of each root was resected. The teeth were randomly divided as follows: Group 1 (20teeth): retrograde preparation using ultrasonic

tip; Group 2 (20teeth): retrograde preparation using sonic tip; Group 3 (4teeth): negative control; Group 4 (4teeth): positive control. Freshly mixed super EBA cement was placed into the root-end cavity. Apical leakage was evaluated using anaerobic bacterial leakage model with *Fusobacterium nucleatum* (VPI 10197) for 30days. 80% (n=16) of the ultrasonically prepared group showed leakage, while 75% (n=15) of the sonically prepared group showed leakage after 30days. Analysis of the data yielded no statistically significant differences in leakage between the groups ($p>0.05$)

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