Influence of plugger penetration depth on the apical extrusion of root canal sealer in Continuous Wave of Condensation Technique

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ABSTRACT

The purpose of this study was to evaluate the influence of plugger penetration depth on the apical extrusion of root canal sealer during root canal obturation with Continuous Wave of Condensation Technique.

Root canals of forty extracted human teeth were divided into four groups and were prepared up to size 40 of 0.06 taper with ProFile. After drying, canals of three groups were filled with Continuous Wave of Condensation Technique with System B™ and different plugger penetration depths of 3, 5, and 7 ㎜ from the apex. Canals of one group were filled with cold lateral compaction technique as a control. Canals were filled with non-standardized master gutta-percha cones and 0.02 mL of Sealapex. Apical extruded sealer was collected in a container and weighed. Data was analyzed with one-way ANOVA and Duncan's Multiple Range Test.

3 and 5 ㎜ penetration depth groups in Continuous Wave of Condensation Technique showed significantly more extrusion of root canal sealer than 7 ㎜ penetration depth group ($p < 0.05$). However, there was no significant difference between 7 ㎜ depth group in Continuous Wave of Condensation Technique and cold lateral compaction group ($p < 0.05$).

The result of this study demonstrates that deeper plugger penetration depth causes more extrusion of root canal sealer in root canal obturation by Continuous Wave of Condensation Technique. Therefore, special caution is needed when plugger penetration is deeper in the canal in Continuous Wave of Condensation Technique to minimize the amount of sealer extrusion beyond apex.

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Key words : Plugger penetration depth, Root canal sealer, Apical extrusion, Lateral compaction technique, Continuous Wave of Condensation Technique, ProFile

Ⅰ. INTRODUCTION

To obturate the prepared root canal space, lateral compaction technique has been used for many years with advantages of predictability, easiness of use and length control. However, this method has several disadvantages of lack of homogeneity, voids, sealer pools, and less adaptation to canal walls. To achieve more three-dimensional filling of root canal system, warm vertical compaction method was introduced. This technique uses heat to soften the gutta-percha in order to have more adaptation of it to canal wall.

With System B™ Heat Source and Buchanan Plugger™, a new method of warm vertical compaction of gutta-percha has been developed, it was called "Continuous Wave of Condensation

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Technique[1]. This Continuous Wave of Condensation Technique has been reported to be faster, and more effective than the warm vertical gutta-percha technique[1]. However, it still has some problems of length control.

For excellent canal obturation, gutta-percha needs to have good adaptation to root canal wall without any leakage or extrusion of filling materials beyond the apex[2]. In Continuous Wave of Condensation Technique, proper size of Buchanan plugger must be selected and introduced into the canal. Apical sealing effect and adaptability of filling materials have been reported to be influenced by plugger penetration depth[3-6]. Deeper plugger penetration had better adaptability of gutta-percha[5] and better apical seal[6]. However, deeper plugger penetration may cause more extrusion of filling materials beyond apex[3-6]. When canal sealer or gutta-percha or both are heavily extruded into the periradicular tissues, severe inflammatory reaction and patient discomfort are possible[7-9]. Therefore, more study is necessary to have good adaptation of filling material to root canal wall without extrusion of filling materials beyond the apex in the Continuous Wave of Condensation Technique.

Several kinds of techniques have been used to evaluate the amount of apically extruded filling materials quantitatively in root canal obturation: gutta-percha and sealer with radiographic parameter[10], with magnifying glass and naked eyes[11,12], gutta-percha with electronic balance[13]. However, more accurate quantitative comparison of extrüded canal sealer is necessary.

Therefore, the purpose of the present study was to quantitatively evaluate the influence of plugger penetration depth on the apical extrusion of root canal sealer during root canal obturation by Continuous Wave of Condensation Technique.

Ⅱ. MATERIALS AND METHODS

1. Selection of the teeth

Forty recently extracted human mandibular teeth with single canal were used. Teeth were confined that have root curvature of less than 5 degree and apical foramen of size 15. After evaluation of the canal width at 6, 7, and 8 ㎜ levels from root apex with mesiodistal and buccolingual radiographic films, teeth with severe variation in canal dimension was excluded. All the teeth were horizontally cut with a slow speed diamond saw (Isomet™, Buehler Co., Lake Bluff, IL, U.S.A.) to have 19 ㎜ of tooth length.

2. Root canal preparation

All the root canals were prepared by one operator. Canal patency was established by placing size 10 K-file (Dentsply-Maillefer, Ballaigues, Switzerland) into the canal. After access cavities were made, canal orifice was flared with size 2-4 Gates Glidden drills (Mani®, Nakaakutsu, Japan). Canal of the coronal two-thirds was instrumented sequentially with size 40-25, ProFile® 0.06 taper (Dentsply-Maillefer, Ballaigues, Switzerland) at a constant speed of 300 r.p.m. in a crown-down manner. Working lengths were determined by placing size 10 K-files in the canals until it was visible at the apical foramen and subtracting a half millimeter. Apical canal preparation was sequentially instrumented with size 25 - 40, 0.04 taper and size 35, 0.06 taper ProFiles, and completed with size 40, 0.06 taper to the working length. Root canals were irrigated after each instrument with alternate use of 1 mL of 15% EDTA and 5 mL of 2.52% sodium hypochlorite (NaOCl) solutions with a 25-gauge needle. Root canal was irrigated with 2.52% NaOCl solution finally. Patency of apical foramen was determined again and maintained by passing a size 10 K-file through the foramen. After completing the root canal preparation, canals were divided into four groups, three for Continuous Wave of Condensation Technique with different plugger penetration depths and one for cold lateral compaction technique as a control (Table 1). To avoid desiccation, all teeth were stored in 100% humidity until canal obturation.

Table 1. Experimental groups with different plugger penetration depths from the root apex.

Group	*n*	Plugger penetration depth from apex
Ⅰ	10	3 mm from root apex with CWCT*
Ⅱ	10	5 mm from root apex with CWCT
Ⅲ	10	7 mm from root apex with CWCT
Ⅳ	10	Cold lateral compaction technique

CWCT*: Continuous Wave of Condensation Technique

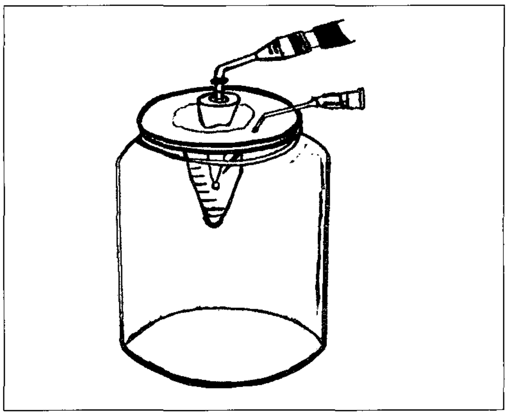

Figure 1. Diagram of experimental unit for the root canal obturation and collection of extruded root canal sealer

3. Preparation of operating fields

Each tooth was positioned in a rubber top by forcing its root in the hole made in the center of the top. An empty 1.5 mL microcentrifuge tube was attached to the rubber top as a collecting container for extruded canal sealer. The rubber top with the tooth and the collecting container was positioned at the top of glass bottle. A 22-gauge plastic syringe needle was placed through the rubber top to equalize the air pressure between the inside and outside of the tube. Operating field was covered with aluminum foil to simulate clinical situations (Figure 1).

4. Preparation for canal obturation

For Continuous Wave of Condensation Technique, non-standardized gutta-percha cones of medium size (Diadent, Chungju, Korea) were selected for master cones and their tips were cut to make size 40 by the use of a gutta-percha gauge (Dentsply-Maillefer, Ballaigues, Switzerland) and no. 15 scalpel. A System B™ and Buchanan's pluggers (Analytic Tech., Redmond, WA, U.S.A.) were used as heat sources. Proper size of plugger was selected for each root canal. The depths of plugger penetration were 3, 5 or 7 ㎜ from the working length. For lateral compaction technique, standardized gutta-percha cones of size 40 (Diadent, Chungju, Korea) were selected for master cones and their tip sizes were confirmed by the use of a gutta-percha gauge. Proper sizes of finger spreader were selected. Root canals were dried with sterile paper points. Root canal sealer, Sealapex® (Kerr Sybron, Romulus, MI, U.S.A.) was mixed according to manufactures' recommendations. Standardized 0.02 mL of sealer was delivered in each canal with the master cone via a 1 mL plastic syringe.

5. Canal obturation

The master cone with root canal sealer was placed to 0.5 ㎜ short of working length and the pre-fitted Buchanan's Plugger was activated with System B and inserted into the root canal to 3, 5 or 7 ㎜ from the working lengths for the Continuous Wave of Condensation Technique. After removing the plugger, a hand plugger was used for vertical compaction. Remaining coronal canal space was obturated with the multiple incremental backfilling technique by the use of Obtura II™ (Texceed, Costa Mesa, CA, U.S.A.)[14]. Canals of the control group were obturated by the cold lateral compaction technique.

6. Collection and quantification of extruded root canal sealer

All the new collection tubes were placed in a desiccator at 110℃ for 24 hours to remove moisture before canal obturation. At no time was the inner collection tube touched with fingers; clean poly gloves were always worn. The entire apparatus was handled only by the outer glass bottle.

After canal obturation, apical 5 ㎜ of external root surfaces was flushed with 1.0 mL of 95% alcohol to collect the extruded sealer. After separation from each tooth, collecting tubes with root canal sealer were placed in a desiccator at 110℃ for 24 hours. An electronic balance (A&D Company, Tokyo, Japan) was used to weigh the collecting tube and collected sealer. The amount of extruded sealer was calculated by subtracting the weight of the collecting tube from the total weight of the collecting tube and extruded sealer. The vials were weighed three times respectively and the mean values were obtained. Since weights of empty vials were not consistent during measuring, values of less than 0.1 mg level were discarded. The weight of each collecting tube and extruded sealer was recorded to 1.0 ㎎ level.

7. Statistical analysis

The mean weights of extruded canal sealer were compared using one-way ANOVA. Duncan's Multiple Range Test was used to determine significant differences in extruded sealer.

Ⅲ. RESULTS

The mean weight of apically extruded root canal sealers were as follows: 2.0 ± 1.2 ㎎ in Group Ⅰ, 1.8 ± 0.8 ㎎ in Group Ⅱ, 0.7 ± 0.7 ㎎ in Group Ⅲ, while no sealer was extruded in Group Ⅳ. Therefore, 3 and 5 ㎜ penetration depth groups in Continuous Wave of Condensation Technique (Groups Ⅰ and Ⅱ) showed significantly more extrusion of root canal sealer than 7 ㎜ penetration depth group in Continuous Wave of Condensation Technique (Group Ⅲ) and cold lateral compaction group (Group Ⅳ) ($p < 0.05$) (Figure 2). However, there was no significant difference between 3 ㎜ depth group (Group Ⅰ) and 5 ㎜ depth group (Group Ⅱ) in Continuous Wave of Condensation Technique and between 7 ㎜ depth group in Continuous Wave of Condensation Technique (Group Ⅲ) and cold lateral compaction group (Group Ⅳ).

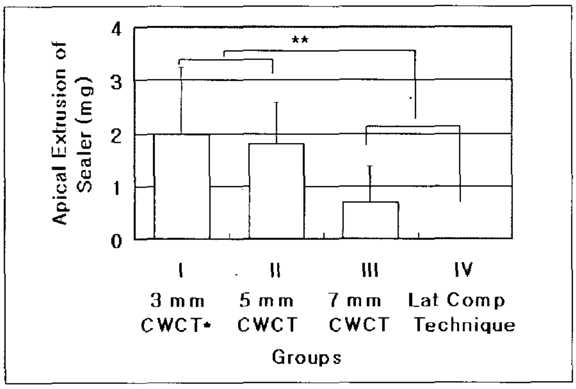

Figure 2. The amount of extruded root canal sealer.
* Apical 3, 5, and 7 ㎜ of plugger penetration depth in Continuous Wave of Condensation Technique (CW-CT).** Significantly different ($p < 0.05$).

Ⅳ. DISCUSSION

Like in any other thermoplasticized gutta-percha techniques[15,16], Continuous Wave of Condensation Technique faces with some possibility of overextension of filling materials. Even though a very small amount of gutta-percha extending from the apical foramen may ensure a three-dimensional seal of apex[17], overextension of the filling material produces periapical tissue irritation which can be detrimental to repair, possible potential for patient discomforting, and a greater incidence of failure[11].

There have been several efforts to reduce apical extrusion of filling material in Continuous Wave of Condensation Technique: plugger penetration depth[3-6], plugger penetration force[18-20], master cone adaptability[21-23], master cone movement[24,25], physical properties of gutta-percha and root canal sealer[26-28], apical foramen size and apical enlargement[15,28-30], apical patency[13], root canal shape[28], root curvature[31], etc. The present study was to evaluate the influence of plugger penetration depth on the apical extrusion of root canal sealer.

Deeper application of heat was recommended in Continuous Wave of Condensation Technique to allow the plugger to penetrate to within 5 ㎜ of the working length to have effective compaction of the apical gutta-percha and to obtain an effective apical seal[4]. With deeper penetration depth, better surface adaptation of gutta-percha[3,5] and less apical leakage[6] were also reported. However, Kim and Kim[6] reported risk of more apical extrusion of filling material with deeper plugger penetration depth.

In the present study, more apical extrusion of sealer was found with deeper penetration depth. 3 and 5 mm penetration depth groups in Continuous Wave of Condensation Technique showed significantly more extrusion of root canal sealer than 7 mm penetration depth group in Continuous Wave of Condensation Technique and cold lateral compaction group.

The ability of an obturation technique to fill the root canal system three dimensionally depends on partially on the timing and intensity of force applications. In the Continuous Wave of Condensation Technique, System B™ uses a heat plugger that simultaneously heats and pushes gutta-percha. The plugger was used to soften and move the gutta-percha apically during the down-pack stage. This system was suggested to be one of the best techniques in terms of the developed vertical force and resulting wedging effect in relationship to the plasticity of gutta-percha[19]. The resultant more extrusion of canal sealer and more compaction of apical gutta-percha with deeper penetration depth may be explained by the wedging effect created by the intracanal force developed during down-packing, and the result of the hydrostatic pressure in the canal by the vertical force[19,20].

Size of apical foramen or apical canal may influence on the apical extrusion of gutta-percha. Size of apical foramen is different from tooth to tooth[32]. In studies comparing apical extrusion of gutta-percha with different size of apical canal[25,30], apical cone displacement and overextension of gutta-percha was not found when the apical root canals were shaped up to a size 25 file, while extrusion of gutta-percha was frequently noted when canal was enlarged to size 40. In the present study, teeth were confined that has apical foramen of size 15, and the canals were enlarged to the same sizes each other. No gutta-percha extrusion was shown in the present study. When apical part of gutta-percha cone is undersized, the wedging effect is decreased by compactions reaching the undersized part of the gutta-percha cone[19,20]. At this stage, extrusion of apical part of the cone and heavy root canal sealers will be occurred.

The quality of cone fitting, to a great extent, reflects the relative prognosis for long term success of treatment. Use of gutta-percha cones of slightly less taper than the canal preparation[23] was recommended which ensures that it is binding only in its apical millimeter. When a cone of too much taper is used, it binds in the body of the canal rather than at its terminus, resulting in an apical underfill. Tug-back short of the cone tip is also a setup for overextension of the cone during condensation procedures. Kwon and Kim[21] reported that, in canals prepared up to size 35 ProFile® of .06 taper, non-standardized medium sized gutta-percha cone that has a taper of 0.053 occupied significantly more canal space than any other cones studied. Therefore medium sized non-standardized gutta-percha cones were used in the present study to have good apical adaptation.

The amount of apically extruded debris or sealer is very little[33,34]. Since the collected material in the present study contained sealer and irrigation solution together, it was desiccated in a desiccator to remove the moisture, and weighed with an electronic balance. The weight of extruded sealer was calculated by measuring the difference of the measured weight of vial between before and after desiccation of the vials. There was a slight change of vial weight only in the last digit value in the lateral compaction group, and extruded sealer cannot be absolutely zero in that group. However, the last digit of the measured value by an electronic balance was not reliable, the values of the last digit, that is less than 0.1 mg level were discarded in the study. As the result, the weight of sealer was shown to be zero the lateral compaction group.

Under the condition of this study, penetration of plugger to apical 3 or 5 mm in Continuous Wave of Condensation Technique showed to cause more extrusion of root canal sealer than penetration of plugger to apical 7 mm in Continuous Wave of Condensation Technique or lateral compaction technique. It is concluded that care should be taken when plugger is placed deep in the canal in Continuous Wave of Condensation Technique to fill the root canal. Further study is necessary on the influence of apical foramen size on apical extrusion of root canal sealer.

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국문초록

플러거 삽입깊이가 근관실러의 치근단 정출에 미치는 영향

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Continuous Wave 가압법으로 근관충전시 플러거 삽입 깊이에 따른 근관실러의 치근단 정출을 평가하고자 직선형의 단근관 및 15번 크기의 치근단공을 가지는 발거된 40개의 치아에서 0.06 경사도 40번 크기가 되게 니켈-티타늄 전동화일인 ProFile®로 근관을 형성하고 플러거 삽입깊이를 근단 3, 5 또는 7 ㎜로 하여 System B™를 이용한 Continuous Wave 가압법 및 측방가압법으로 근관을 충전하였다. 치근단으로 정출된 근관실러의 무게를 측정하여 일원변량분석법과 Duncan's Multiple Range Test로 통계분석하였다.

플러거 삽입깊이 3 ㎜ 또는 5 ㎜의 Continuous Wave 가압 충전군은 삽입깊이 7 ㎜ 가압충전 군 및 측방가압 충전군에 비해 유의하게 많은 근관실러의 치근단 정출을 나타내었다 ($p < 0.05$). 그러나 플러거 삽입깊이 3 ㎜ 군과 5 ㎜ 군 사이 및 플러거 삽입깊이 7 ㎜ Continuous Wave 가압군과 측방가압 군 사이에는 유의한 차이가 나타나지 않았다 ($p > 0.05$). 본 연구의 결과로 보아 Continuous Wave 가압법으로 근관충전시에는 플러거 삽입깊이가 깊을수록 근관실러의 치근단 정출이 많음을 알 수 있다.