

Influence of plugger penetration depth on the area of the canal space occupied by gutta-percha

Young Mi Lee, Ho-young So, Young Kyung Kim, Sung Kyo Kim*

Department of Conservative Dentistry, School of Dentistry, Kyungpook National University

ABSTRACT

To evaluate the ratio of gutta-percha area in the canal after canal obturation with Continuous Wave of Condensation Technique (CWCT) with varying depths of plugger penetration, forty root canals of extracted human teeth were prepared up to size 40 of 0.06 taper with ProFile[®]. Canals of three groups were filled with CWCT with System B[™] (Analytic Tech., USA) and different plugger penetration depths of 3, 5, or 7 mm from the apex. Canals of one group were filled with lateral condensation technique as a control. The filled teeth were cross-sectioned at 1, 2, and 3 mm levels from the apical foramen. The ratio of gutta-percha area in the canal was analyzed using Auto[®]Cad 2000. Data were analyzed with one-way ANOVA and Duncan's multiple range test.

At all levels, higher gutta-percha area ratio was found with deeper plugger penetration depth in CWCT, and cold lateral condensation group showed higher ratio than group of plugger penetration to apical 7 mm in CWCT.

At apical 1 mm and 2 mm levels, group of plugger penetration to apical 3 mm showed significantly higher gutta-percha area ratio than those of apical 7 mm and lateral condensation ($p < 0.05$).

It is concluded therefore that, under the conditions of the present study, deeper plugger penetration depth results in more favorable and efficient obturation in CWCT. [J Kor Acad Cons Dent 31(1):66-71, 2006]

Key words: Plugger penetration, Gutta-percha area ratio, Continuous Wave of Condensation Technique, Canal obturation, System B

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I . Introduction

Since there is tremendous variance in the anatomy of the root canal system, numerous techniques have been advocated to achieve the ideal root

canal fillings¹⁾. Beginning with the vertical condensation technique²⁾, various modifications in materials or procedures have been developed to improve obturation³⁾. A reported advantage of a thermoplasticized vertical compaction technique is the ability to soften gutta-percha so that it can be molded to various configurations within the root canal system⁴⁾.

One of the modifications, Continuous Wave of Condensation Technique (CWCT)⁵⁾ uses a plugger attached to a heat source to vertically compact the gutta-percha in one motion. The proposed

* Corresponding author: **Sung Kyo Kim**

Department of Conservative Dentistry, School of Dentistry, Kyungpook National University
188-1, Samdeok-Dong 2-Ga, Jung-Gu, Daegu 700-412, Korea
Tel: 82-53-420-5935 Fax: 82-53-426-8958
Email: skykim@knu.ac.kr

advantages of this technique are the reduced time that is required to perform the downpack of thermoplasticized gutta-percha and its convenience⁵⁾.

Upon penetration depth of plugger in warm gutta-percha technique, the tip of plugger was recommended to be fit within 5 mm to 7 mm from most canal termini⁵⁾. With leakage test, deeper penetration showed less leakage both in conventional vertical condensation technique⁶⁾ and CWCT⁷⁾.

Both gutta-percha and sealer were used to fill root canals, and each made its own contribution to the seal achieved. Gutta-percha is dimensionally stable, whereas most sealers dissolve over time. The dissolution of the sealer is probably responsible for increase in leakage along the root fillings over time⁸⁾. Thus a good adaptation of gutta-percha to the canal wall promotes the complete obturation of the root canal space. Reducing the amount of sealer and the ratio of sealer to gutta-percha in the root filling promotes the long-term seal provided by the root filling⁸⁾. Hence, the quality of obturation needs to be evaluated by other method.

Therefore, the purpose of this study was to evaluate the ratio of gutta-percha area in the canal after canal obturation with CWCT with varying depths of plugger penetration.

II . Materials and methods

1. Selection of the teeth and Root canal preparation

Forty recently extracted single rooted human mandibular teeth were used. Teeth were confined that have root curvature of less than 5 degree and apical foramen of size 15. All the teeth were

horizontally cut at the crown with a microtome (IsometTM, Buehler Co., Lake Bluff, IL, USA) to have 19 mm of root length.

All the root canals were prepared by one operator. After access cavities were made, canal orifices were flared with size 2 to 4 Gates Glidden drills (Mani[®], Nakaakutsu, Japan). Canal patency was established by placing size 10 K-file (Dentsply-Maillefer, Ballaigues, Switzerland) into the canal until it could just be seen flush with the external root surface at the apical foramen. Canal of the coronal two-thirds was instrumented sequentially with size 40 to 25, 0.06 taper ProFile[®] (Dentsply-Maillefer, Ballaigues, Switzerland) in a crown-down manner. Apical canal was sequentially instrumented with size 25 to 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. After completing the root canal preparation, canals were divided into four groups (Table 1). All teeth were stored in 100% humidity until canal obturation.

2. Canal obturation

For the CWCT, non-standardized gutta-percha cones of medium size (Diadent, Chungju, Korea) were selected for master cones⁹⁾ and their tips were cut to make size 40 by the use of a gutta-percha cone gauge (Dentsply-Maillefer, Ballaigues, Switzerland). For lateral compaction technique, standardized gutta-percha cones of size 40 (Diadent, Chungju, Korea) were selected for mas-

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

Group	n	Plugger penetration depth from working length
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	Lateral Compaction Technique

* Continuous Wave of Condensation Technique.

ter cones. A root canal sealer, Sealapex® (Kerr Sybron, Romulus, MI, USA), was mixed according to manufacture's recommendation.

The master cone with root canal sealer was placed to 0.5 mm short of working length and gently pumped up and down for the proper sealer distribution. After placing the master gutta-percha cone within 0.5 mm from the working length in the canal, the pre-fitted Buchanan's Plugger was activated with System B (Analytic Tech., Redmond, WA, USA) and inserted into the root canal to 3, 5 or 7 mm from the working lengths for the CWCT. 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, USA). Canals of the control group were obturated by the cold lateral compaction technique. All teeth were stored in a humidior at 37°C and 100% humidity for setting of the sealer.

3. Preparation of specimen and measurement of area ratio

The canal-filled teeth were embedded in auto-polymerizing acrylic resin (Orthodontic Resin, Dentsply/Detrey, Konstanz, Germany) molds. All blocks were cross-sectioned at 1.0, 2.0 and 3.0 mm levels from the apical foramens with a microtome (Isomet™, Buehler Co., Lake Bluff, IL, USA). Each section was stored in a computer using a commercial digitizing image program (miroVIDEO Studio 200 program, Pinnacle system, Brauschweig, Germany).

After tracing the periphery of the root canal and gutta-percha cone area using a digitizer (Intuos™, Wacom Company Ltd., Saitama, Japan), the ratio of gutta-percha area in the cross-sectional area of the canal were calculated using a computer program (Auto®Cad 2000, Autodesk Corp., San Rafael, CA, USA) at each apical level.

Data of gutta-percha area ratio were analyzed with one-way ANOVA and Duncan's multiple range test. P value of less than 0.05 was regarded significant.

III. Results

Figure 1 shows cross-sectional views of canal at each level and Figure 2 shows the ratio of gutta-percha area at each level in different groups. In general, there was tendency that deeper penetration of plugger induced more gutta-percha area ratio.

At apical 1 mm level, 3 mm CWCT group showed significantly higher gutta-percha ratio than 7 mm group and lateral compaction group ($p < 0.05$). However, there was no significant difference between 3 mm and 5 mm CWCT groups, and among 5 mm group, 7 mm group and lateral compaction group.

At apical 2 mm level, 3 mm CWCT group showed significantly higher gutta-percha ratio than 7 mm group and lateral compaction group ($p < 0.05$). 5 mm CWCT group showed significantly higher gutta-percha ratio than lateral compaction group ($p < 0.05$). However, there was no significant difference between 3 mm and 5 mm CWCT groups, between 5 mm and 7 mm CWCT groups, and between 7 mm CWCT group and lateral compaction group.

At apical 3 mm level, 3 mm and 5 mm CWCT groups showed significantly higher gutta-percha ratio than 7 mm group ($p < 0.05$). However, there was no significant difference among 3 mm CWCT group, 5 mm group and lateral compaction group and between 7 mm CWCT group and lateral compaction group ($p > 0.05$).

IV. Discussion

Incomplete obturation of the root canal system may ultimately lead to an endodontic failure^{10, 11}. For long term success, as little as possible on an absorbable paste and as much as possible on a solid core material, which resists absorption, is well accepted by the specialty of endodontics^{12, 13}.

In the present study, higher gutta-percha area ratio was found with deeper plugger penetration depth in CWCT on the observation of the cross-sectioned specimen at all levels. These findings are in agreement with the results of Wu *et al.*⁸ who found that the mean percentage of gutta-percha-filled area decreased from 96.1% when heated to

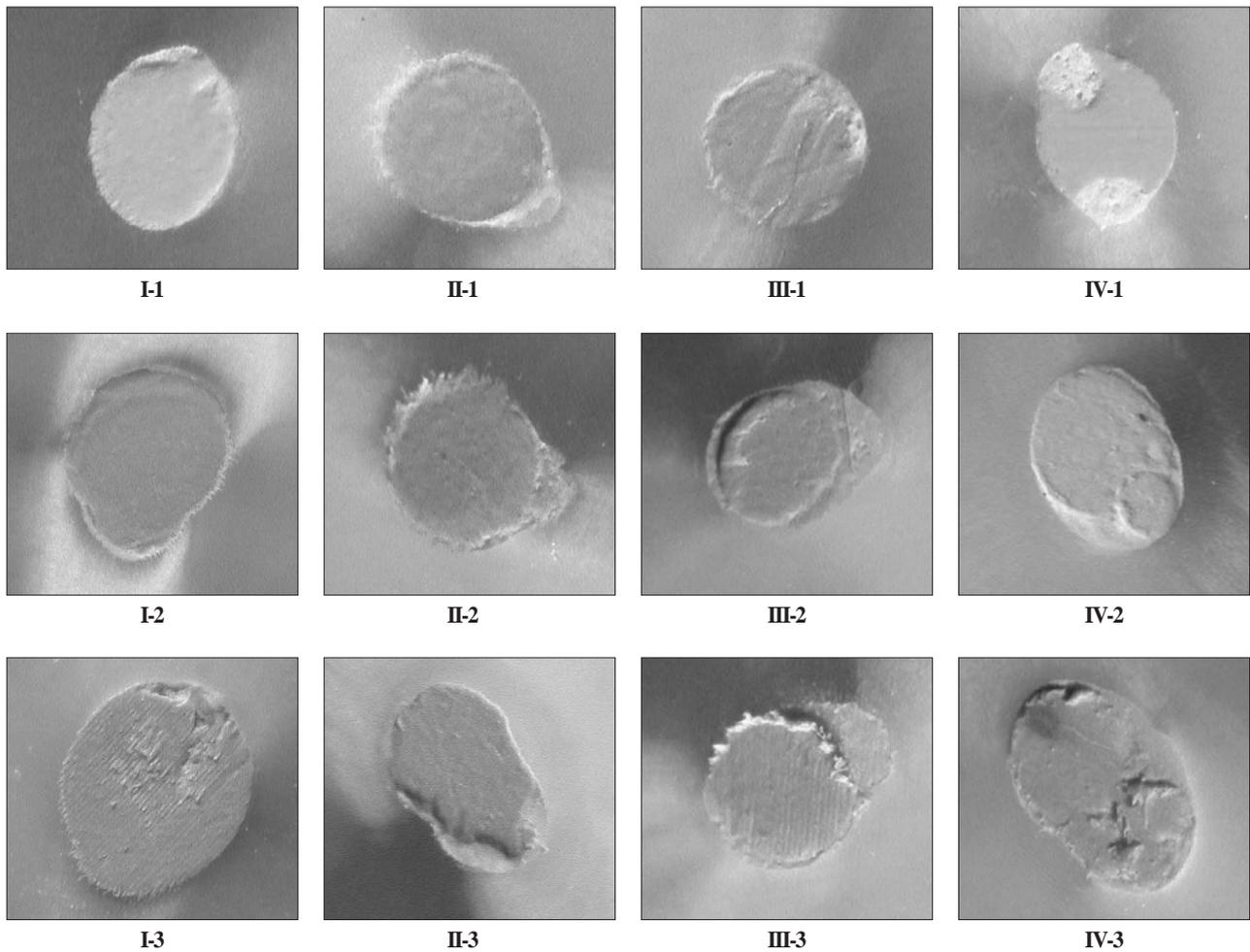


Figure 1. Cross-sectional view at each level, first letters are expression of each group and last letters are distances (mm) from apical construction to each cross-sectional level.

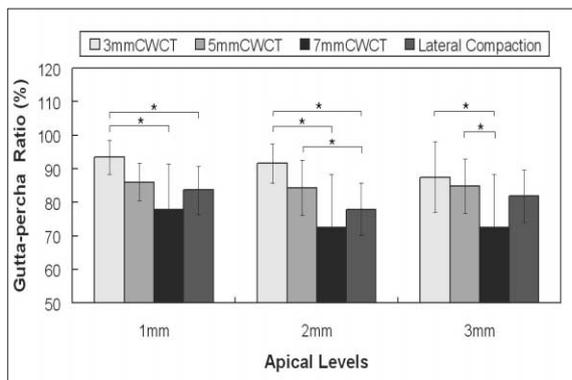


Figure 2. The ratio of gutta-percha area (% , mean \pm S.D.) with different plugger penetration depth in Continuous Wave of Condensation Technique (CWCT). * significantly different ($p < 0.05$).

apical 2 mm to 87% when heated to apical 4 mm. These findings may be explained by a report⁴⁾ that deeper plugger penetration group showed better movement of gutta-percha flow in depressed root canal by using the System B for the CWCT.

In the present study, at apical 1 mm level, group of plugger penetration to apical 3 mm showed significantly higher gutta-percha ratio than those of apical 7 mm and cold lateral compaction groups. These findings were caused by different depth of applied heat. In other words, apical gutta-percha of 7 mm plugger penetration group probably was not heated sufficiently, because the heat applied during compaction by vertical condensation technique travels only 3 to 4 mm into the remaining

gutta-percha¹⁾. Marlin and Schilder¹⁴⁾ also reported a similar result that gutta-percha was softened apically 4 to 5 mm from contact point of heat device when root canal was obturated by vertical condensation technique. In all the experimental groups in the present study, 1 mm level showed higher gutta-percha ratio than 3 or 5 mm levels. The reason of this may be that master cones were fitted at most termini of root canal. This reason may explain the phenomenon that there was no significant difference of gutta-percha area ratio at 1 mm level among 5 mm and 7 mm plugger penetration groups and cold lateral compaction group. With different plugger penetration depths in CWCT, deeper application of heat was recommended to allow the plugger to penetrate to within 5 mm of the working length to have effective compaction of the apical gutta-percha and to obtain an effective apical seal⁶⁾. With deeper penetration depth, better surface adaptation of gutta-percha^{4,11)} and less apical leakage were also reported⁷⁾.

The results of this study demonstrates that deeper penetration depth of plugger causes higher gutta-percha ratio of the canal space in CWCT. Even though some previous studies reported tendency of more apical extrusion of filling material with deeper plugger penetration depth^{7,15)} in CWCT, many of the more contemporary obturation techniques advocate canal obturation to within 0.5 mm of the radiographic apex, to the radiographic apex, or beyond, which is confirmed by the presence of a "puff" of filling material¹⁾. Schilder²⁾ described that an overfilled tooth is one whose root canal system has been filled in three dimensions, and where a surplus of material extrudes beyond the foramina. He reported that any case of endodontic failure due to overfilling was never encountered. On the other hand, there were numerous cases of failure of vertical overextensions of underfilled root canals²⁾. Because primary cause for failure of root canal treatment was the apical percolation of fluids and microorganisms into a poorly obturated root canal system¹⁾, hermet-

ic seal of root canal was more important than the adverse effects of over-extensional filling materials for successful endodontic treatment¹⁵⁾. Therefore, it is concluded that deeper plugger penetration depth results in more efficient obturation in CWCT in terms of gutta-percha area ratio. Further research is needed on its influence in patients.

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국문초록

Plugger 삽입깊이가 근관내 gutta-percha 점유면적에 미치는 영향

이영미 · 소호영 · 김영경 · 김성교*

경북대학교 치의학대학원 치과보존학교실

Continuous Wave 가압법으로 근관충전시 plugger 삽입 깊이에 따른 근관내 gutta-percha 비율을 평가하고자 40개의 발거치아 근관을 0.06 경사도 40번 크기의 ProFile®로 근관을 형성하고 세 군에서는 plugger 삽입깊이를 근단 3, 5 또는 7 mm로 하여 System B™를 이용하여 Continuous Wave 가압법으로 충전하였고, 한 군에서는 대조군으로서 측방가압법으로 근관을 충전하였다. 충전된 근관은 치근단 1, 2 및 3 mm 수준에서 횡절단하여 근관내 gutta-percha 면적비를 계산하고 일원변량분석법을 이용하여 통계분석 하였다.

모든 절단수준에서, Continuous Wave 가압법으로 충전한 군 사이에서는 plugger의 삽입깊이가 깊을수록 높은 gutta-percha 면적비를 나타내었고, 측방가압법으로 충전한 군이 plugger의 삽입깊이를 7 mm로 충전한 군보다 높은 gutta-percha 면적비를 나타내었다 ($p < 0.05$).

주요어: 플러거 삽입, 가타과차 비율, Continuous Wave of Condensation Technique, 근관충전, System B