치의학박사 학위논문

Correlation between tug-back and cone fitness in curved root canals prepared with reciprocating files

Reciprocating motion 니켈-티타늄 전동 파일로 형성한 만곡근관에서 cone의 적합도와 tug-back의 상관관계

2015년 2월

서울대학교 대학원

치의과학과 치과보존학 전공

윤 희 영

Abstract

Correlation between tug-back and cone fitness in curved root canals prepared with reciprocating files

Heeyoung Yoon

Program in Conservative Dentistry

Department of Dental Science

Graduate School, Seoul National University

(Directed by Prof. WooCheol Lee, D.D.S., M.S.D., Ph.D.)

Objectives.

The purpose of this study was to compare the gutta-percha-occupied area (GPOA) of two gutta-percha cones with different size and taper using micro-computed tomographic (micro-CT) imaging and to evaluate the relationship between GPOA and tug-back in curved root canals instrumented with reciprocating files.

Methods.

Twenty curved roots from extracted human maxillary and mandibular molars were divided into two groups. In group R (n = 10), root canals were prepared with Reciproc R25 files (VDW, Munich, Germany) and in group W (n = 10), root canals were prepared using WaveOne Primary files (Dentsply Maillefer, Ballaigues, Switzerland). The presence or absence of tug-back was decided for both of #25/.08 and #30/.06 gutta-percha cones in every root canal. Micro-CT imaging was used to analyze cone fitness by calculating the percentage of GPOA at 1-, 2-, and 3-mm levels from the working length. The correlation between the sum of the GPOA from all three levels and the presence of tug-back was also investigated. The data were analyzed statistically. The level of significance was set at 5%.

Results.

Tug-back was present in 45% and 100% root canals for #25/.08 and #30/.06 cones, respectively, with a significant difference ($P < .05$). At the 2- and 3-mm levels, #30/.06 cones produced significantly higher GPOA in both group R and W ($P < .05$). The sum of the GPOA score was significantly higher in the samples with tug-back than in those without tug-back (88.12% ± 12.17% vs. 75.35% ± 13.42%; $P < .05$); however, there was no significant difference between the two cone types for this correlation ($P > .05$).

Conclusion.

Under the conditions of this study, tug-back can be a definitive determinant for indicating higher cone fitness in the curved root canal prepared with reciprocating files regardless of the cone type.

Keywords: cone fitness, gutta-percha occupying area, micro-computed tomography, reciprocating file, tug-back

Student Number: 2011-31185

Contents

Correlation between tug-back and cone fitness in curved root canals prepared with reciprocating files

Heeyoung Yoon, D.D.S., M.S.D.

Program in Conservative Dentistry

Department of Dental Science

Graduate School, Seoul National University

(Directed by Prof. WooCheol Lee, D.D.S., M.S.D., Ph.D.)

1. Introduction

Root canal obturation is an important procedure in endodontic treatment because an adequate sealing of the root canal space promotes the periapical healing and prevents the failure of treatment (1). Gutta-percha (GP) cone is a material of choice in most of the obturation procedures. To create a fluid-tight seal of the root canal, a GP cone should be tightly adapted to the root canal wall. Inadequate or under-filled root canal may lead to reduced success of treatment; therefore, proper selection of the GP master cone is an

important step in the obturation procedure. Clinicians usually prefer to choose manufacturers' GP cones that match the taper and diameter of the master apical size nickel-titanium (NiTi) rotary files. Root canal obturation with such matching GP cones is claimed to provide a three-dimensional obturation in less time with equal or superior quality of adaptation to traditional lateral condensation technique (2, 3).

Because the process of cleaning and shaping of the root canal determines not only the degree of disinfection but also the ability to obturate the radicular space, the quality of obturation is dependent on the root canal preparation. According to the study of Wu et al (4), apical transportation of over than 0.3 mm increased the risk of leakage along apical root fillings. Therefore, it is essential not to create unwanted errors during the instrumentation for the ultimate sealing. A new reciprocating single-file preparation system of the entire root canal with only one file has recently been introduced. This single-file system is designed to be used with a dedicated reciprocating motion motor and alternates between clockwise and counterclockwise rotation during the shaping procedure.

A previous study demonstrated that this system had excellent centering ability with very low apical transportation value of less than 0.138 mm (5). Root canal shaping with reciprocating motion showed lower transportation value than with continuous motion when using the same file system (6, 7). When compared with the usage of multiple file instrumentation techniques, the reciprocating single-file system showed similar shaping outcomes with regard to the root canal curvature, volume, and straightening (8, 9). In another study, root canal preparation with this system better maintained the original canal

anatomy, with less modification of the canal curvature compared with the multiple-file system (10). Commercially available single-file reciprocating systems are composed of three files; Small, Primary, and Large for WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) and R25, R40, and R50 for Reciproc (VDW, Munich, Germany), respectively. It is claimed by the manufacturers that root canals prepared with either WaveOne Primary or Reciproc R25 single-file systems are designed to fully shape the majority of all root canals and have ISO size 25 and 8% taper (#25/.08) in the apical 3 mm. Gordon et al (2) reported that the root canal obturation using matched-taper GP cone was effective for the root canals prepared with the same taper NiTi file; thus, when the root canal is instrumented with either WaveOne Primary or Reciproc R25 files, then the root canal is ready to be obturated with a corresponding #25/.08 GP cone.

However, instrumented root canals may have bigger lumens than the designated file size (5, 11). If tug-back is inadequate with the matching GP cone, it is necessary to select another size and/or taper cone with sufficient fitness confirmed with tug-back because the tug-back with the GP master cone is recommended in order to create and maintain the apical seal. Tug-back is the slight resistance to removal of the GP cone from the root canal. It is used as a tactile indicator for proper master cone adaptation; however, it is a subjective determinant that cannot be quantitatively measured. Objective assessment of the adaptability of the GP cone could be performed by calculating the percentage of the GP cone occupying the canal space (2, 12-15) or by measuring the distance between GP mass and the root canal wall (3). Thus, it would be helpful in selecting the proper GP

cone if one could visualize the relationship between the presence of tug-back and the fit of the GP cone occupying the canal space. Cross-sections necessary for analysis could be obtained from histological sectioning or from imaging modalities. Micro-computed tomography (micro-CT) has been introduced as a nondestructive technique and has become popular in the study of the tooth structure. In the field of endodontic research, this technique is used to evaluate the root canal anatomy, to compare the root canal morphology before and after instrumentation, and to assess the quality of root canal obturation (16, 17). No study could be found concerning the cone fitness in comparison with tug-back after the root canal preparation, especially instrumented with single-file reciprocating systems.

The aims of this study were (1) to compare the adaptability of various GP cones by measuring the gutta-percha-occupied area (GPOA) using micro-CT imaging and (2) to correlate these GPOA with the presence or absence of tug-back in the apical 3 mm of the curved root canals prepared with single-file reciprocating systems.

2. Materials and Methods

Root Canal Selection

Twenty curved roots from extracted human maxillary and mandibular molars were used in this study. Mesiobuccal and distobuccal roots of the maxillary molars and mesial roots of the mandibular molars with fully formed apices were used. Roots with previous root canal treatment, fractures, resorption, or open apices were excluded. The power analysis was conducted using G*power 3.1 software (Franz Faul, Universität Kiel, Germany) and a sample size of ten canals in each group was sufficient to detect important differences (alpha = 0.05, 80% power). Soft tissue and mineralized deposits on the root surface was removed using periodontal curettes, and the occlusal surface of each tooth was flattened perpendicular to the long axis. The teeth were accessed using #4 round high-speed burs and the root canals were negotiated with #10 stainless steel K-files (Dentsply Maillefer, Ballaigues, Switzerland) until the tips were visible at the apical foramina. The working lengths were set at 1 mm from this measured length. A digital radiograph was taken in the bucco-lingual direction to determine the canal curvature according to Schneider's method (18). After measuring the working length, a glide path was formed using a #15 stainless steel K-file. Figure 1 summarizes the study procedures.

Root Canal Preparation

The roots were divided into two groups of 10 each by stratification of the curvature in order to ensure even distribution. The root canals were prepared by one operator with experience with NiTi rotary files and with the single-file reciprocating systems (ie, Reciproc and WaveOne). In group R (n = 10), the root canals were prepared to the working length using Reciproc R25 files, and in group W (n = 10), the root canals were prepared with WaveOne Primary files. A new file was used in every root canal. The files were operated with a dedicated engine for reciprocating motion (Reciproc Silver; VDW, Munich, Germany) with each recommended setting; Reciproc files with the "RECIPROC ALL" mode and WaveOne with the "WAVEONE ALL" mode. The files were used with gentle strokes of in-and-out pecking motion until the working length was reached, and after three consecutive strokes, the files were inspected and debris was wiped off with gauze. At the working length, instrumentation was performed with one pecking motion. 5.25% sodium hypochlorite was used for irrigation, and patency of the root canal was maintained throughout the experimental procedure.

Micro-CT Analysis

After completion of the preparation procedure, each root canal was dried with paper points. Then #25/.08 GP cones (Dia-Pro R and Dia-Pro W for Reciproc and WaveOne respectively; DiaDent, Cheongwon, Korea) and #30/.06 GP cones (Sure-endo; Sure-dent Co, Seoul, Korea) were sequentially inserted to the working length of the same root canal

to compare the adaptation of the cones from each other. Tug-back was recorded as either "yes" or "no" (all-or-none) for both #25/.08 cones and #30/.06 cones in the root canals when they reached the respective working lengths or when the cones fitted with tug-back to within 1 mm of the working length. The GP master cones were stabilized using sticky wax for immobilization.

A customized jig for the micro-CT scanning was fabricated with acrylic resin so that the tooth could be placed in the same position with the two different GP cones. Each tooth was mounted with the crown positioned downwards and its long axis perpendicular to the floor of the specimen holder of the micro-CT and the x-ray source. The samples were scanned using a desktop micro-CT x-ray scanner (SkyScan 1172; SkyScan b.v.b.a., Aartselaar, Belgium) at a voltage of 100 kV and a current of 100 μA with a 0.5 mm aluminum filter. The cross-sectional pixel size and intersection distance were 16 μm. The acquisition procedures consisted in the attainment of several two-dimensional lateral projections of the samples during a rotation around the vertical axis. The digital data were constructed by reconstruction software (NRecon V1.6.9; SkyScan) providing axial cross sections. The cone adaptability was assessed at 1-, 2-, and 3-mm levels from the working length using micro-CT imaging (Figure 2). From these images the analysis of the percentage of GPOA was performed using image analysis software (CTAn V1.14.4; SkyScan) (Figure 3). For each slice, regions of interest (ROI) were chosen to each contain a single root canal. Then the gray level image was segmented into a GP core and void by a process called thresholding. This process was used for the binarization of the

reconstructed images by classifying the pixels according to whether or not their gray levels exceed a given threshold value. Area of selected pixels ($pexel^2$) could be obtained from the individual 2D analysis and the percentage of GPOA was calculated by dividing GPOA by the sum of void area and GPOA.

Data Analysis

The GPOA at each level was compared using the Wilcoxon signed rank test and the Friedman test. The sum of GPOAs (sGPOA) from all three levels was computed, and the correlation between the tug-back and the sGPOA was analyzed using Mann-Whitney test. The Chi-square and Fisher's exact test were used to compare the sGPOA and tug-back between the experimental groups. The significance level was set at $P < .05$.

3. Results

All 20 files used for root canal preparation showed no visible deformation or fractures. There existed no significant difference between group R and group W in the distribution of the root canal curvature. The teeth in group R presented 21.0 ± 7.8° of average curvature, whereas the teeth in group W presented 22.6 ± 8.2°.

Of the 20 root canals tested for cone fitness, only 45% (9 canals) of dedicated #25/.08 cones showed tug-back, whereas all 20 root canals those were tested with #30/.06 cones showed tug-back in the curved root canals. This difference between two types of cones was statistically significant in both file groups ($P < .05$) (Table 1). There was no significant difference between the two reciprocating file systems with regard to the tug-back with either size of cones ($P > .05$).

When comparing the measurements obtained from micro-CT analysis, the mean values, and standard deviations of the percentage of GPOA at each level are demonstrated in Table 2 and Figure 4. There was no significant difference of the percentage of GPOA between #25/.08 cones and #30/.06 cones at the 1-mm level in both group R and group W ($P > .05$). However, at the 2- and 3-mm levels, #30/.06 GP points showed significantly higher GPOA scores than dedicated #25/.08 cones in both groups ($P < .05$). When sGPOA was compared, there was no significant difference between the two GP cone types regardless of file system used (Table 1).

In the presence of tug-back, sGPOA scores were 88.12% ± 12.17%, whereas for the

no tug-back samples, they were 75.35% ± 13.42%, respectively. Mann-Whitney test revealed that sGPOA score was significantly higher in the samples with tug-back ($P < .05$).

4. Discussion

Once the instrumented root canal is ready to obturate, clinicians confirm the GP cone fitness to the canal by feeling tug-back. However, a clinical significance of tug-back correlated with GP-filled area within the root canal has not been made clearly yet. Therefore, this study was performed in order to verify the clinical importance of tug-back in the root canals prepared with reciprocating NiTi rotary file systems.

NiTi files are designed to be manufactured with greater taper than the conventional ISO standard hand files with .02 taper. With the increased use of NiTi rotary files currently, there is an increased preference for the use of matching cones with continuous wave of condensation and/or warm vertical condensation rather than conventional lateral condensation technique using standardized GP cones. Concerns have been raised whether these single designated GP cone obturation techniques are suitable with respect to sealing ability. Several studies were conducted to compare the sealing ability of these techniques with other commonly used techniques with various methods such as dye penetration (19), fluid filtration (20-22), bacterial leakage (23), and photomicrographic evaluation (24). In this regard, a number of previous studies confirmed that the obturation technique using a nonstandardized GP cone is comparable with lateral condensation in obturation quality (2, 3, 14, 25). Although a number of studies have compared conventional lateral condensation with the single-cone technique (12-14, 26, 27), very few have evaluated the quality of obturation in root canals prepared with reciprocating file systems.

It was reported that the increased number of pecks at the working length during instrumentation using reciprocating single file system would increase the apical size of the preparation from the actual size of the instrument being used (11). Although the reciprocating single-file system presented similar or better shaping ability than continuous multiple-file system with regard to the tendency of preserving the original canal shape (8-10), a slight overinstrumentation could be another factor that contributes increased apical size (5). Accordingly, the selected GP cone corresponding to the size and taper of the NiTi rotary instrument used in root canal preparation might have insufficient tug-back. Because root canal shaping instruments have a tendency of straightening the root canal during preparation, apical transportation may be another factor that causes unreliable cone fitness, especially in curved root canals (28). Therefore, cone fitness would be a concern for the root canal filling, especially in cases prepared using reciprocating file systems. There have been no guidelines for determining tug-back as a determinant for selecting a proper GP master cone for desirable obturation outcomes.

In the present study, effort was focused on evaluating criteria for selecting a GP master cone with better adaptability by correlating tug-back with GPOA where tug-back is subjectively tactile and GPOA is the visualized objective score. Previous studies have evaluated the percentage of the GP-filled area after complete obturation of individual root canals but did not provide simultaneous comparison of tug-back with the GP-filled area (2, 12, 13, 15, 27). In contrast, this study compared the GPOA in the same root canal with two different sizes and tapers of GP cones adapted. In the present study, the micro-CT

analysis of 1, 2, and 3 mm from the working length was performed because the most critical area of the root canal preparation occurs in the last 2 mm from the apex (29), and most of tug-back would be sensed in this part of the root. In the cross section of these levels, GP cone with tug-back contacted one side and opposing surface of root canal wall. The micro-CT data obtained from this study could directly provide the GPOA and the correlation between tug-back and GPOA, thus allowing the selection of a better-fitting cone for favorable root canal obturation.

The micro-CT technique has several advantages over other methods such as dye leakage test and histological sectioning for evaluating root canal obturation because it is nondestructive and allows the preservation of sample integrity to avoid irreversible structural damage. Moreover, micro-CT data have showed qualitative and quantitative correlation with histological examination (16).

In this study, tug-back showed significant correlation with the GPOA from micro-CT images, which might show the actual fitness between the cone and root canal wall at the critical apical 3 mm. This implies that tug-back could be an indicator for the master cone selection during the obturation procedure. This finding is contrary to the study of Allison et al (30), who reported that tug-back was not accurate in predicting lateral fit. In their study, the fitness of GP cones was evaluated with two-dimensional radiography. This difference in methodology may explain the contrast in the results of studies.

The nonmatching #30/.06 cones used in this study showed significantly higher GPOA at 2- and 3-mm levels than dedicated #25/.08 GP cones of both reciprocating file systems.

At the 1-mm level, four samples of group W and one sample of group R were showed greatly reduced GPOA scores when #30/.06 GP cones were adapted, while the other samples presented higher GPOA with #30/.06 cones than with #25/.08 cones. It may explain why there was no significant difference in the percentage of GPOA at this level between two GP points. Nevertheless, the overall GPOAs at all 3 levels (sGPOA) were about 83% and 86% for #25/.08 and #30/.06 cones, respectively, and there was no significant difference between the two types of GP cones. Therefore, #30/.06 cones might be accepted as an equivalent alternative to #25/.08 matching cones in the curved root canals prepared with WaveOne Primary or Reciproc R25 systems. In fact, 80.53% of canal space in group W and 91.26% in group R, which were matched with 100% tug-back in the canal, were occupied with the #30/.06 GP cones. In contrast to the result that sGPOA of matching cones was similar to that of #30/.06 cones, less than 50% of the samples showed tug-back with the matching cones. This was because sGPOA was dependent on the presence or absence of tug-back but not on the number of root canals that showed tug-back. If the nonmatching #30/.06 cone cannot provide tug-back, then the matching cone with the hybrid technique (25) should be chosen as an alternative option. Based on the results of this study, either #25/.08 or #30/.06 GP point with tug-back would provide acceptable cone fitness in the curved root canals instrumented with WaveOne Primary or Reciproc R25 files; however, at the most apical part of the root canal, the GPOA scores of #30/.06 cones showed large standard deviation. Therefore, in clinical practice, adjustment of the #25/.08 cone until the tug-back being achieved may result in

more reproducible obturation outcome.

Considering the present results, even under the condition that the GP cones have their designated sizes, there could be space discrepancies up to 19% between the GP cone and the root canal wall after instrumentation with reciprocating NiTi rotary files. This is because of the instruments' mechanical properties such as restoring force and/or repetitive pecking motions at working length, which may cause a bigger apical preparation than the actual size of the file (11). Dimensional variability of GP cones within and between GP brands produced during manufacturing and storage may contribute to this space discrepancy (31). It disturbs the perfect fit between the GP master cone and root canal wall with friction and diminishes tug-back. Nevertheless, the remaining space that was not occupied with the master GP cone would be filled with sealer and/or heat-plasticized GP during lateral or vertical compaction procedures.

Within the limitations of this study, a size- and taper-tailored GP cones did not provide superior root canal adaptation; rather, tug-back would be a better determinant for master cone selection in the root canals prepared with reciprocating files. The evaluation of GP-filled apical areas with various methods, such as micro-CT analysis and stereoscopic microscopic examination of the histologic section after completion of the obturation procedure using the criteria in this study, appears to be beneficial in evaluating clinical outcomes.

5. References

1. Schilder H. Filling root canals in three dimensions. Dent Clin North Am 1967;11:723-44.
2. Gordon M, Love R, Chandler N. An evaluation of .06 tapered gutta-percha cones for filling of .06 taper prepared curved root canals. Int Endod J 2005;38:87-96.
3. Hembrough MW, Robert Steiman H, Belanger KK. Lateral condensation in canals prepared with nickel titanium rotary instruments: an evaluation of the use of three different master cones. J Endod 2002;28:516-9.
4. Wu M-K, Fan B, Wesselink PR. Leakage along apical root fillings in curved root canals. Part I: effects of apical transportation on seal of root fillings. J Endod 2000;26:210-6.
5. Goldberg M, Dahan S, Machtou P. Centering ability and influence of experience when using WaveOne single-file technique in simulated canals. Int J Dent 2012;2012:206321.
6. Franco V, Fabiani C, Taschieri S, Malentacca A, Bortolin M, Del Fabbro M. Investigation on the shaping ability of nickel-titanium files when used with a reciprocating motion. J Endod 2011;37:1398-401.
7. Hwang YH, Bae KS, Baek SH, Kum KY, Lee W, Shon WJ, Chang SW. Shaping ability of the conventional nickel-titanium and reciprocating nickel-titanium file systems: a comparative study using micro–computed tomography. J Endod

2014;40:1186-9.

8. Bürklein S, Hinschitza K, Dammaschke T, Schäfer E. Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne versus Mtwo and ProTaper. Int Endod J 2012;45:449-61.
9. Paqué F, Zehnder M, De-Deus G. Microtomography-based comparison of reciprocating single-file F2 ProTaper technique versus rotary full sequence. J Endod 2011;37:1394-7.
10. Berutti E, Chiandussi G, Paolino DS, Scotti N, Cantatore G, Castellucci A, Pasqualini D. Canal shaping with WaveOne Primary reciprocating files and ProTaper system: a comparative study. J Endod 2012;38:505-9.
11. Jeon HJ, Paranjpe A, Ha JH, Kim E, Lee W, Kim HC. Apical enlargement according to different pecking times at working length using reciprocating files. J Endod 2014;40:281-4.
12. De-Deus G, Reis C, Beznos D, de Abranches AMG, Coutinho-Filho T, Paciornik S. Limited ability of three commonly used thermoplasticized gutta-percha techniques in filling oval-shaped canals. J Endod 2008;34:1401-5.
13. Jarrett I, Marx D, Covey D, Karmazin M, Lavin M, Gound T. Percentage of canals filled in apical cross sections – an *in vitro* study of seven obturation techniques. Int Endod J 2004;37:392-8.
14. Romania C, Beltes P, Boutsioukis C, Dandakis C. *Ex-vivo* area-metric analysis of root canal obturation using gutta-percha cones of different taper. Int Endod J

2009;42:491-8.

15. Schäfer E, Köster M, Bürklein S. Percentage of gutta-percha–filled areas in canals instrumented with nickel-titanium systems and obturated with matching single cones. J Endod 2013;39:924-8.

16. Jung M, Lommel D, Klimek J. The imaging of root canal obturation using micro-CT. Int Endod J 2005;38:617-26.

17. Rhodes JS, Ford TR, Lynch JA, Liepins PJ, Curtis RV. Micro-computed tomography: a new tool for experimental endodontology. Int Endod J 1999;32:165-70.

18. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol 1971;32:271-5.

19. De Moor R, Hommez G. The long-term sealing ability of an epoxy resin root canal sealer used with five gutta percha obturation techniques. Int Endod J 2002;35:275-82.

20. Inan U, Aydin C, Tunca YM, Basak F. In vitro evaluation of matched-taper single-cone obturation with a fluid filtration method. J Can Den Assoc 2009;75:123.

21. Wu M-K, Bud MG, Wesselink PR. The quality of single cone and laterally compacted gutta-percha fillings in small and curved root canals as evidenced by bidirectional radiographs and fluid transport measurements. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108:946-51.

22. Yilmaz Z, Deniz D, Ozcelik B, Sahin C, Cimilli H, Cehreli ZC, Kartal N. Sealing efficiency of BeeFill 2in1 and System B/Obtura II versus single-cone and cold lateral compaction techniques. Oral Surg Oral Med Oral Pathol Oral Radiol Endod

2009;108:e51-5.

23. Taşdemir T, Er K, Yildirim T, Buruk K, Çelik D, Cora S, Tahan E, Tuncel B, Serper A. Comparison of the sealing ability of three filling techniques in canals shaped with two different rotary systems: A bacterial leakage study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108:e129-34.

24. Nica LM, Didilescu A, Rusu D, Bacila A, Stratul SI. Photomicrographic evaluation of the apical sealing capacity of three types of gutta-percha master cones: an *in vitro* study. Odontology 2012;100:54-60.

25. Guess GM, Edwards KR, Yang ML, Iqbal MK, Kim S. Analysis of continuous-wave obturation using a single-cone and hybrid technique. J Endod 2003;29:509-12.

26. Lea CS, Apicella MJ, Mines P, Yancich PP, Parker MH. Comparison of the obturation density of cold lateral compaction versus warm vertical compaction using the continuous wave of condensation technique. J Endod 2005;31:37-9.

27. De-Deus G, Gurgel-Filho E, Magalhaes K, Coutinho-Filho T. A laboratory analysis of gutta-percha-filled area obtained using Thermafil, System B and lateral condensation. Int Endod J 2006;39:378-83.

28. Kim HC, Cheung GSP, Lee CJ, Kim BM, Park JK, Kang SI. Comparison of forces generated during root canal shaping and residual stresses of three nickel–titanium rotary files by using a three-dimensional finite-element analysis. J Endod 2008;34:743-7.

29. Hayes SJ, Dummer PM. Late failure of root canal therapy: a diagnostic and treatment

planning challenge. Case report. Int Endod J 1997;30:68-71.

30. Allison DA, Michelich RJ, Walton RE. The influence of master cone adaptation on the quality of the apical seal. J Endod 1981;7:61-5.

31. Cunningham KP, Walker MP, Kulild JC, Lask JT. Variability of the diameter and taper of size #30, 0.04 gutta-percha cones. J Endod 2006;32:1081-4.

Tables and Figures

Table 1. Sum of gutta-percha-occupied area (sGPOA) from 3 levels and the number of canals with tug-back with two different gutta-percha cones for each group.

Cones	Group W		Group R	
	sGPOA mean ± SD	Tug-back	sGPOA mean ± SD	Tug-back
#25/.08	80.71 ± 16.67	5/10*	85.93 ± 9.43	4/10*
#30/.06	80.53 ± 16.12	10/10†	91.26 ± 9.59	10/10†

Group W, WaveOne Primary; Group R, Reciproc R25; SD, standard deviation.

Values with the different symbol in the same column were statistically different at $P < .05$.

Table 2. Mean value ± standard deviation of the percentage of the gutta-percha-occupied area (GPOA) at each level with two different gutta-percha cones of each group.

Cones	Levels	% of GPOA	
		Group W	Group R
#25/.08	1 mm	83.46 ± 16.96	91.36 ± 8.68
	2 mm	80.95 ± 20.55	87.89 ± 9.34
	3 mm	77.71 ± 17.36	78.54 ± 13.05
#30/.06	1 mm	58.78 ± 43.81	89.51 ± 31.47
	2 mm	93.42 ± 13.62	95.38 ± 6.15
	3 mm	89.38 ± 14.63	88.89 ± 7.76

Group W, WaveOne Primary; Group R, Reciproc R25.

* indicate significant difference between two GP cone systems at $P < .05$.

There was no significant difference in the percentage of GPOA between two file systems at $P = .05$.

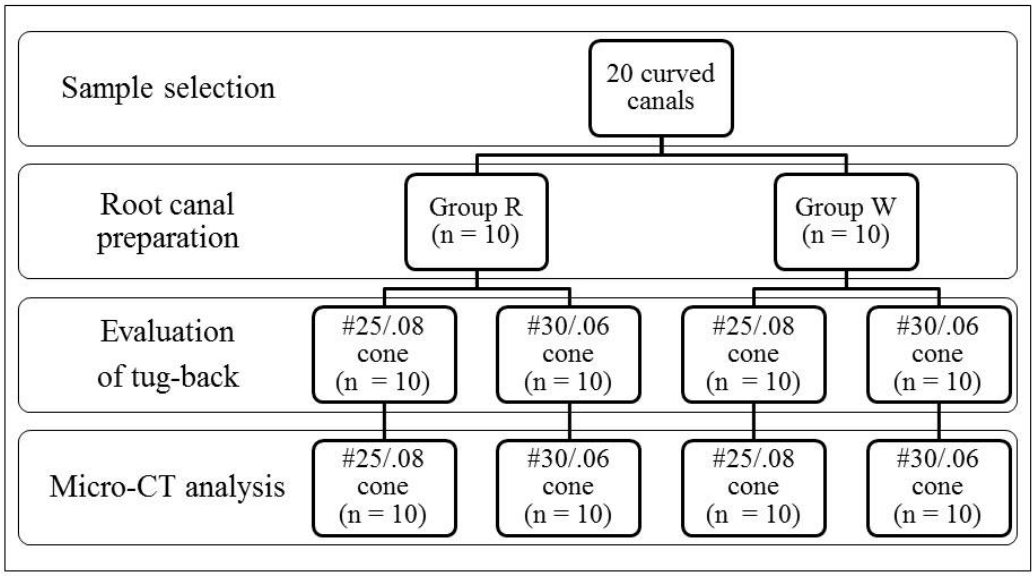
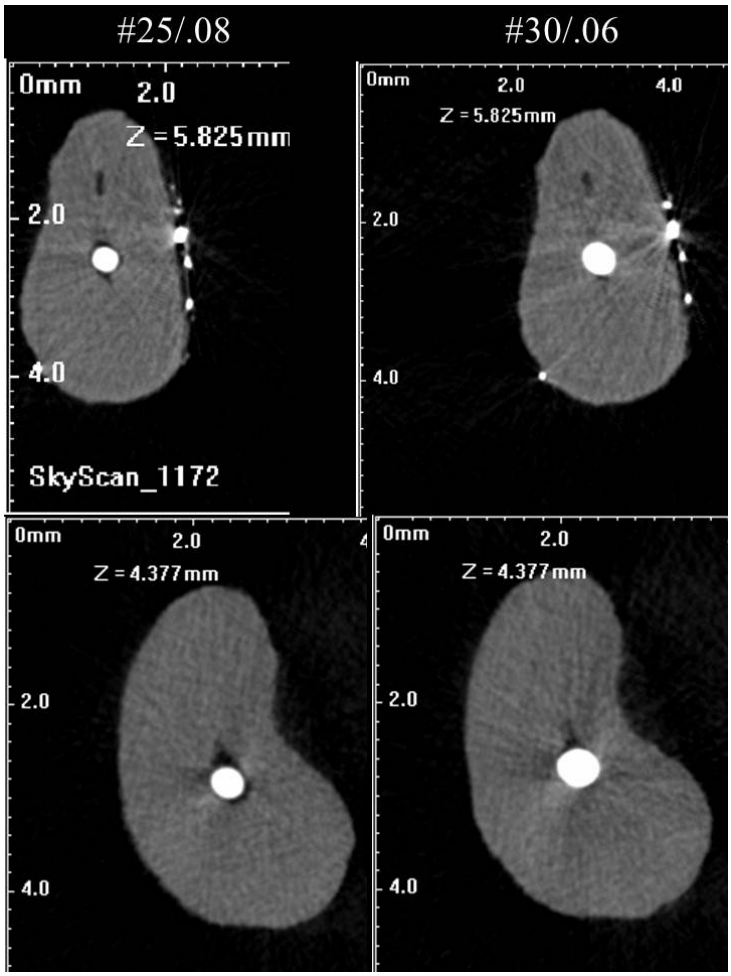


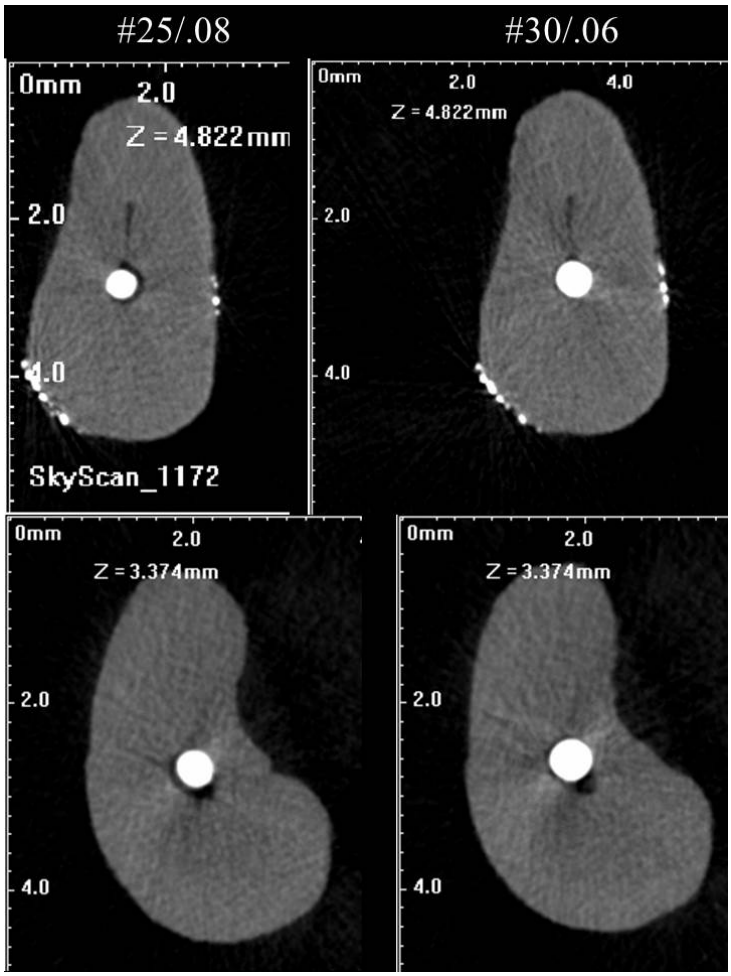
Figure 1. Flow chart summarizing the steps involved in this study.

A


#25/.08
#30/.06
0mm
2.0
Z = 5.825mm
2.0
4.0
SkyScan_1172
0mm
2.0
4.0
Z = 5.825mm
2.0
4.0
0mm
2.0
Z = 4.377mm
2.0
4.0
0mm
2.0
Z = 4.377mm
2.0
4.0

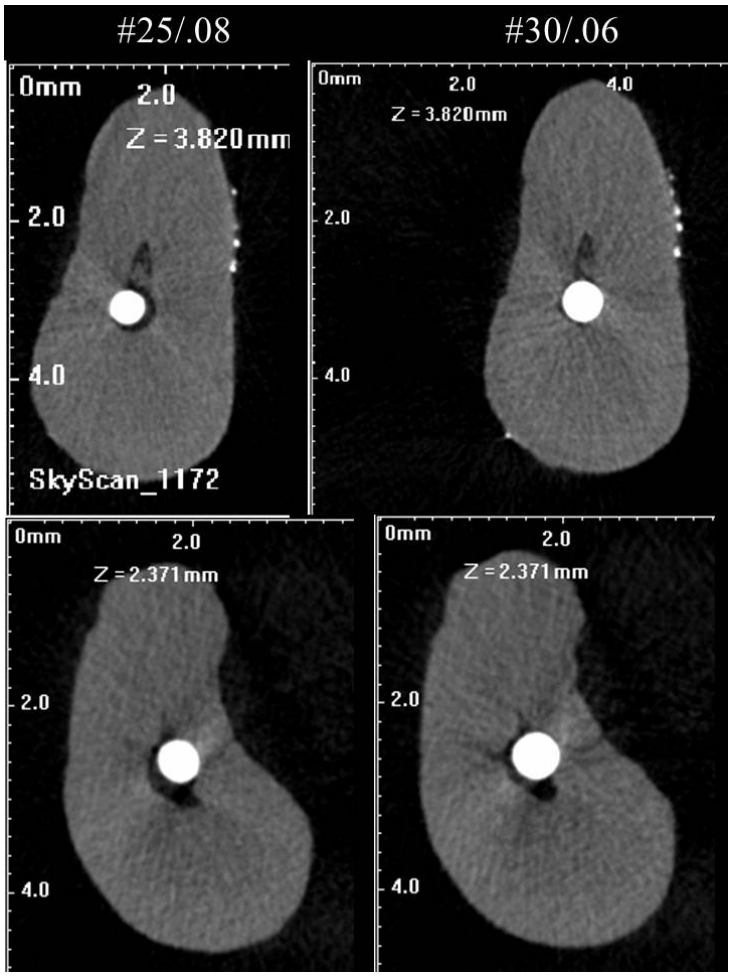
(continued)

B


#25/.08
#30/.06
0mm
2.0
Z = 4.822mm
2.0
4.0
SkyScan_1172
0mm
2.0
4.0
Z = 4.822mm
2.0
4.0
0mm
2.0
Z = 3.374mm
2.0
4.0
0mm
2.0
Z = 3.374mm
2.0
4.0

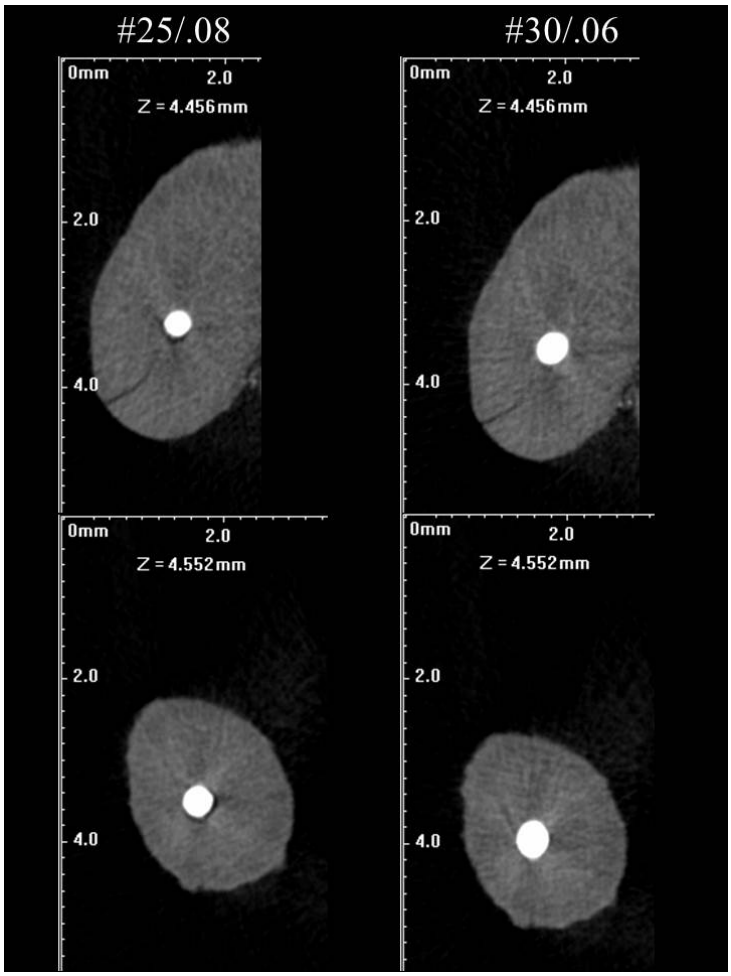
(continued)

C


#25/.08
#30/.06
0mm
2.0
Z = 3.820mm
2.0
4.0
SkyScan_1172
0mm
2.0
4.0
Z = 3.820mm
2.0
4.0
0mm
2.0
Z = 2.371mm
2.0
4.0
0mm
2.0
Z = 2.371mm
2.0
4.0

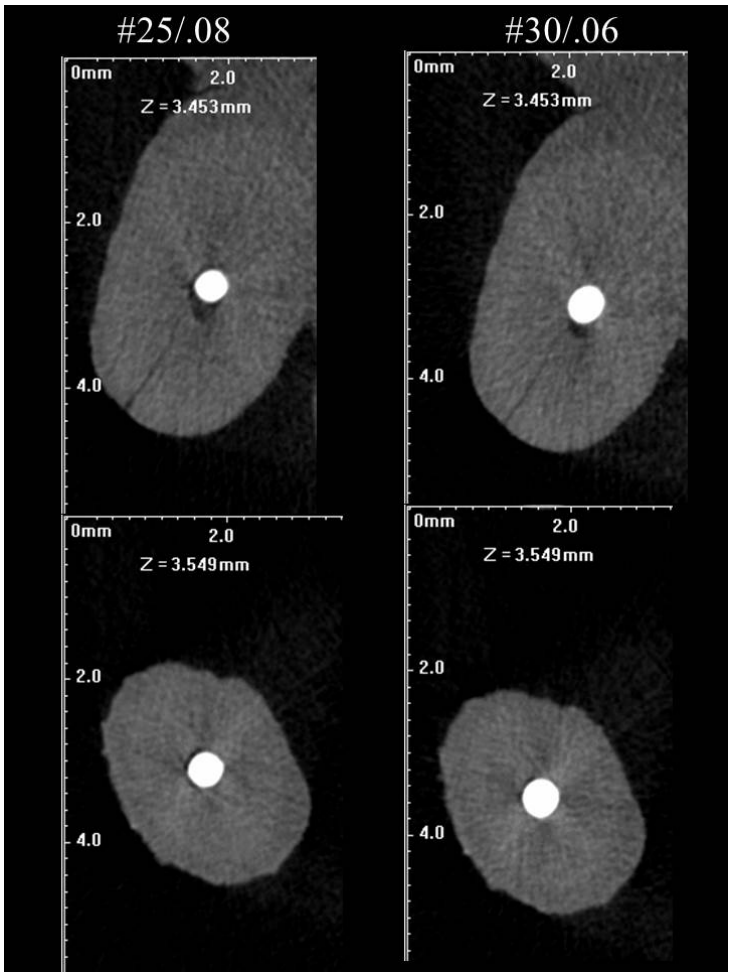
(continued)

D


#25/.08
#30/.06
0mm
2.0
Z = 4.456mm
2.0
4.0
0mm
2.0
Z = 4.456mm
2.0
4.0
0mm
2.0
Z = 4.552mm
2.0
4.0
0mm
2.0
Z = 4.552mm
2.0
4.0

(continued)

E


#25/.08
#30/.06
0mm
2.0
Z = 3.453mm
2.0
4.0
0mm
2.0
Z = 3.453mm
2.0
4.0
0mm
2.0
Z = 3.549mm
2.0
4.0
0mm
2.0
Z = 3.549mm
2.0
4.0

(continued)

F

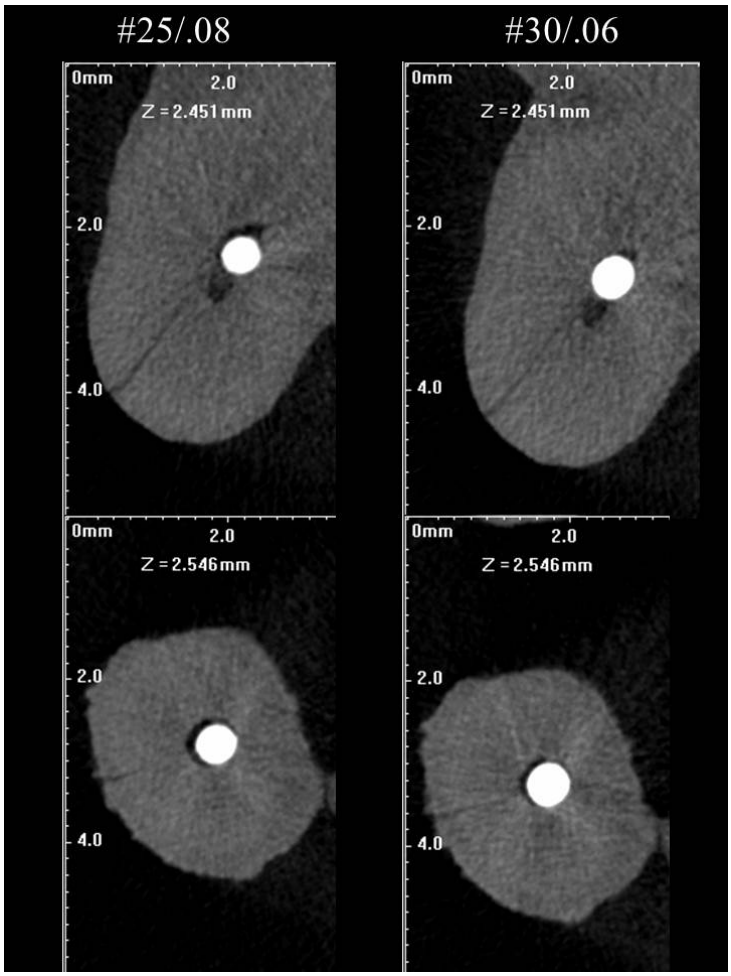


Figure 2. Micro-CT images of cone fitness of two different sizes and tapers of gutta-percha cones. (A) Group W at 1-mm level. (B) Group W at 2-mm level. (C) Group W at 3-mm level. (D) Group R at 1-mm level. (E) Group R at 2-mm level. (F) Group R at 3-mm level.

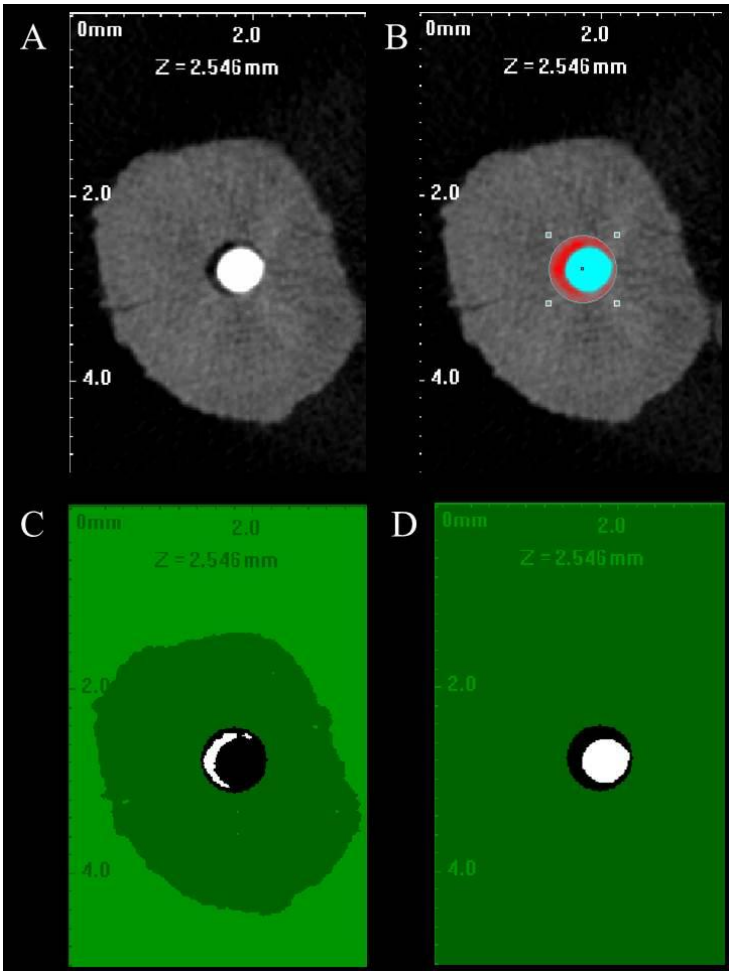


Figure 3. Example of image analysis using image analysis software. (A) Raw image. (B) Selection of region of interest. Image binarization by thresholding for (C) void, and (D) gutta-percha cone.

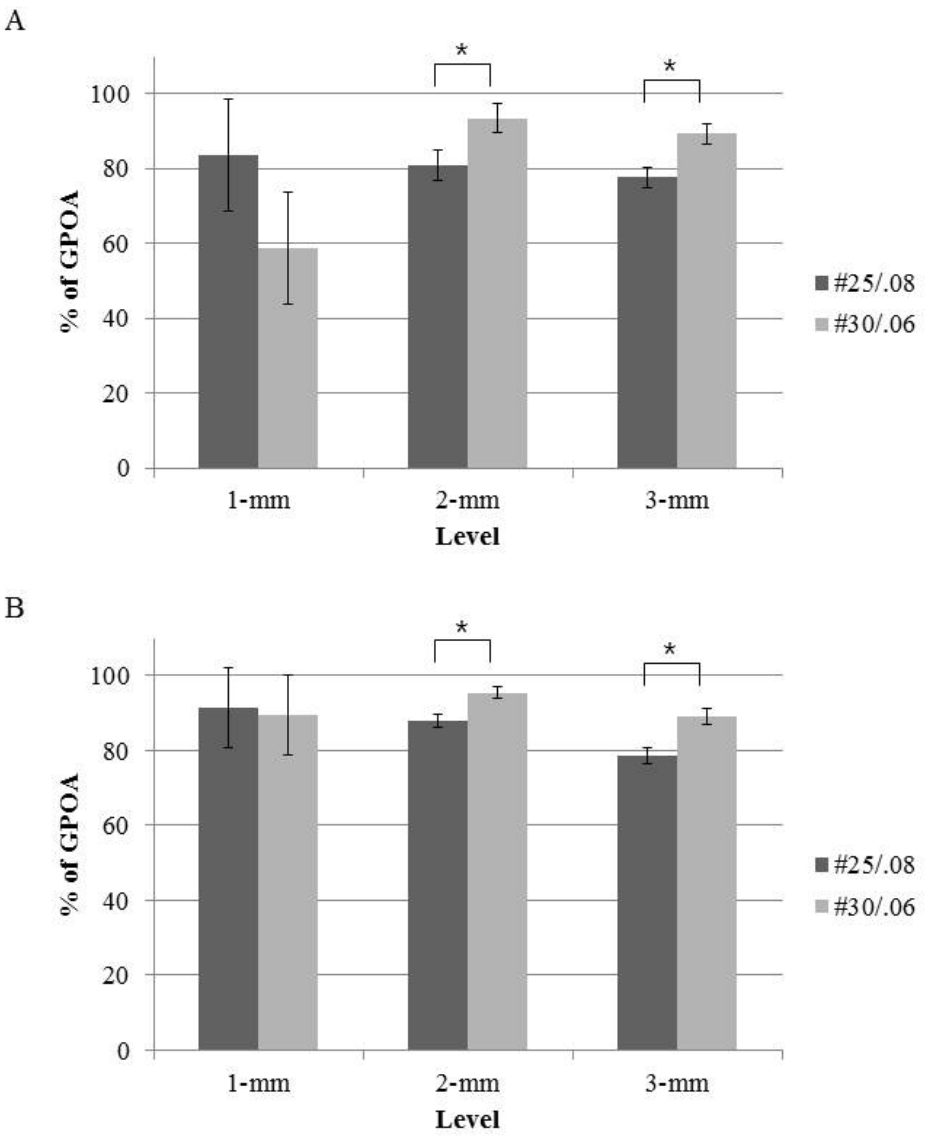


Figure 4. Mean values and 95% confidence intervals of the percentage of gutta-percha-occupied area (GPOA) at each level with two different gutta-percha cones. (A) Group W. (B) Group R. * indicate significant difference between two GP cone systems at $P < .05$.

국문초록

Reciprocating motion 니켈-티타늄 전동 파일로 형성한 만곡근관에서 cone의 적합도와 tug-back의 상관관계

윤 희 영

서울대학교 대학원 치의과학과 치과보존학 전공

(지도교수 이 우 철)

1. 목적

본 연구에서는 reciprocating motion 니켈-티타늄 전동 파일을 이용하여 형성한 만곡근관에 대해 근관 내 gutta-percha cone의 점유면적인 gutta-percha occupied area (GPOA)를 미세 전산화 단층 촬영술을 이용하여 측정하고 평가하여 GPOA와 tug-back 사이의 관계를 알아보고자 하였다.

2. 재료 및 방법

만곡근관 20개를 각각 10개씩 2 개의 군으로 나누어 근관 형성하였다. R 군은 Reciproc R25 파일을, W 군은 WaveOne Primary 파일을 적용하였다. 모든 근관에서 #25/.08과 #30/.06의 두 종류 gutta-percha cone에 대한 tug-back 유무를 기록하였으며 미세 전산화 단층 촬영 영상을 이용하여 근관장으로부터 1, 2, 3 mm 높이에서의 GPOA 백분율을 측정하였다. 근관장으로부터 1, 2, 3 mm 높이에서의 GPOA 백분율의 평균값인 sum of GPOA와 tug-back의 유무 사이의 관계에 대해 분석하였다. 통계적 유의 수준은 P = 0.05로 설정하였다.

3. 결과

#25/.08 cone을 적용한 경우 45%, #30/.06 cone을 적용한 경우 100%의 근관에서 tug-back이 존재하여 통계학적으로 유의한 차이를 보였다 (P < 0.05). 근관장으로부터 2 mm와 3 mm 높이에서는 R 군과 W 군 모두 #30/.06 cone이 #25/.08 cone보다 유의성 있게 높은 GPOA 값을 나타내었다 (P < 0.05). Tug-back이 존재하는 경우에 tug-back이 존재하지 않는 경우에 비해 sum of GPOA 값이 유의성 있게 높았으나 (P < 0.05) 사용한 cone의 종류에 따른 sGPOA 값의 차이는 통계적으로 유의하지 않았다 (P > 0.05).

4. 결론

본 연구 결과에 의하면 reciprocating motion 니켈-티타늄 전동 파일을 이용하여 형성한 만곡근관의 근관 충전에서 tug-back의 존재는 높은 근관 내 적합도를 나타내는 지표로 사용될 수 있다.

주요어: 근관 내 적합도, 미세 전산화 단층 촬영, gutta-percha occupying area, reciprocating motion, tug-back

학 번: 2011-31185