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# Ability of two reciprocating Nickel-Titanium instruments for gutta-percha/sealer removal in simulated curved root canals

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***ABSTRACT***

*The aim of this study was to compare the capacity of two reciprocating NiTi instruments in removing gutta-percha/sealer material from simulated curved root canals (SCRC). The time required for filling material removal was also recorded. Twenty SCRCs were divided into two groups of 10 (n=10) samples each. In Group 1, the SCRC were prepared to a R25 Reciproc Blue instrument (RCPB; VDW, Munich, Germany). In Group 2 the SCRC were prepared to a Primary WaveOne Gold instrument (PWOG; Dentsply, Ballaigues, Switzerland). In both groups, the canals were filled with matched-taper single gutta-percha cones and AH Plus sealer. Filling materials were removed with R25 RCPB (Group 1) and PWOG (Group 2). The amount of remaining gutta-percha/sealer was calculated at three predetermined levels of evaluation located at 2, 6 and 10 mm from the WL and expressed in percentages. Canals re-treated with RCPB contained significantly less remaining gutta-percha/sealer compared to canals prepared with PWOG (P=0.02). The RCPB instruments required significantly less time to complete the retreatment procedures (P<0.01). No unwinding or instrument separation was noted. RCPB instruments removed significantly more gutta-percha/sealer from simulated curved root canals than PWOG. However, neither of the tested instruments completely removed all filling materials.*

***Keywords:*** *Endodontics - gutta-percha - root canal therapy - retreatment.*

## Análisis de la capacidad de dos instrumentos reciprocantes de Niquel-Titanio para la remoción de gutapercha/sellador en conductos curvos simulados

***RESUMEN***

*El propósito del presente estudio fue comparar la capacidad de dos instrumentos de NiTi de movimiento reciproco para remover la obturación de gutapercha/sellador durante el retratamiento de conductos curvos simulados (SCRC). El tiempo requerido para la remoción del material fue también registrado. Se utilizaron veinte (n=20) SCRC divididos en dos grupos de diez especimenes (n=10) cada uno. En el Grupo 1 los SCRC se prepararon hasta un instrumento Reciproc Blue R25 (RCPB; VDW, Munich, Germany). En el Grupo 2, los SCRC se prepararon hasta un instrumento WaveOne Gold Primary (PWOG; Dentsply, Ballaigues, Switzerland). En ambos grupos los conductos se obturaron con cono único de gutapercha de conicidad creciente y el sellador AH Plus. La remoción de los materiales de obturación se realizó mediante los instrumentos RCPB R25 (Grupo 1) o PWOG (Grupo 2). La cantidad de gutapercha/sellador remanente se calculó en tres niveles de evaluación predeterminados ubicados a 2, 6 y 10 mm de la LT, y finalmente fue expresada en porcentajes. La cantidad de gutapercha/sellador remanente en los SCRC retratados con RCPB fue significativamente menor en comparación con los que fueron retratados con PWOG (P=0.02). Los instrumentos RCPB requirieron un tiempo significativamente menor para completar el retratamiento (P<0.01). No se observaron deformaciones o separación de los instrumentos.*

*Los instrumentos RCPB removieron una cantidad significativamente mayor de gutapercha/sellador que los instrumentos PWOG en conductos curvos simulados. Sin embargo, ninguno de los instrumentos ensayados removió completamente los materiales de obturación.*

***Palabras clave:*** *Endodoncia - gutapercha - tratamiento del conducto radicular - retratamiento.*

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## INTRODUCTION

One reason for endodontic failures may be the persistence of bacteria in the root canal system[1]. This may be due to insufficient cleaning, the inability of the practitioner to identify and treat extra canals, or inadequate obturation, leading to the development of periapical pathosis. To re-establish the normal status of the periapical tissues, a non-surgical retreatment approach is the procedure of choice[2-4]. Complete removal of the pre-existing root canal filling materials followed by reinstrumentation, disinfection and obturation of the root canal system is essential for a successful outcome[5]. Historically, different methods have been used for removing filling materials, including hand-operated and engine-driven rotary instruments, some of which have been specifically designed for gutta-percha removal[6-10]. In this respect, two recently introduced reciprocating root canal preparation systems called Reciproc Blue (RCPB; VDW, Munich, Germany) and Wave One Gold (WOG; Dentsply Sirona, Ballaigues, Switzerland) were suggested for non surgical endodontic retreatment[11-13]. The RCPB system consists of three single-use instruments: R25 (25/.08), R40 (40/.06) and R50 (50/.05), which are manufactured using a special heat treatment technology. They have an S-shaped cross section, variable taper and a non-cutting tip[14]. The WOG system consists of four single-use instruments with a parallelogram-shaped cross section: Small (20/.07), Primary (25/.07), Medium (35/.06) and Large (45/.05). The WOG instruments were originally manufactured with heat treated M-Wire alloy, but have recently been changed to GOLD alloy technology. The metallurgical improvements in the RCPB and WOG instruments for increasing their flexibility and resistance to cyclic fatigue have been reported by Keskin et al.[15] and Sarefoglu et al.[16]. To the best of our knowledge, little information is available with respect to the efficacy of RCPB and WOG for removing gutta-percha/sealer.

The purpose of this study was to compare the capacity of RCPB and WOG NiTi instruments in removing gutta-percha/sealer material from simulated curved root canals (SCRC). The null hypothesis was that there would be no significant difference between the instruments in their ability to remove gutta-percha/sealer, and that there would be no difference in the total time required for retreatment.

## MATERIALS AND METHODS

Twenty (n=20) Endo Training Resin Blocks (ETRB; Dentsply Maillefer, Ballaigues, Switzerland) with standardized SCRC 16 mm in length with a round cross-section, a 0.02 continuous taper and a curvature of 40° ± 0.5 were used in this study. After the canals were explored with #10 K-Files (Dentsply Maillefer), the working length (WL) was established from the top of the access opening to the stop end of the simulated canals (16 mm). The ETRB were then randomly divided into two groups of 10 (n=10) samples each.

*Canal preparation and obturation*

To avoid variation, all samples were prepared by a single trained operator using an electric X-Smart IQ motor (Dentsply Sirona) following the predetermined programs for each RCPB or PWOG instrument and according to the manufacturer's instructions. For both groups, the ETRB with the SCRC were mounted on a fixed custom attachment simulating a standardized clinical position. In Group 1, the SCRC were prepared to a R25 RCPB in a reciprocating crown-down motion. The instruments were introduced into the canals until resistance was felt and then used with 3 in-and-out-pecking movements and light apical pressure. The instruments were then removed and cleaned. After irrigation with 3 mL distilled water, the instruments were used again with in-and-out-pecking movements until the WL was reached. The canals were then irrigated with 3 mL distilled water and dried with paper points. The instruments were discarded after each canal preparation. In Group 2, the SCRC were prepared to a Primary WOG instrument (PWOG) using the same operative procedures as in Group 1.

In both groups, the SCRC were filled with the single gutta-percha cone technique[17] and AH Plus sealer (Dentsply, Ballaigues) prepared according to the manufacturers' instructions. The canal walls were coated with a thin layer of the sealer. A single matched-taper gutta-percha cone corresponding to each of the last instruments used for canal preparation was then coated with the sealer and slowly inserted into the canals until the WL was reached. Excess gutta-percha/sealer at the canal orifice was removed with a heated instrument followed by compacting with a plugger (Dentsply Maillefer). After obturation, all filled SCRC were kept at 37°C and 100% relative humidity for 14 days to allow the sealer to set completely.

*Canal Retreatment*

In Group 1, retreatment consisted of gutta-percha/sealer removal with R25 RCPB using a slow in-and-out-pecking motion until the WL was reached. The instruments were used along the entire length of the canal in an in-and-out-pecking motion with a brushing circumferential movement while pressing against the canal walls. This procedure continued until no filling material was observed on the flutes of the instruments as observed with an operating microscope (Newton MEC XXI, BA Argentina). If any gutta-percha/sealer remnants were visible, the process was repeated until no remnants of material were observed. A new instrument was used for each canal and then discarded. In Group 2, retreatment was performed with PWOG. The operative procedures were similar to those described for Group 1. The RCPB and PWOG were used at a fixed speed of 500 rpm with the manufacturer's recommended torque. In both groups, irrigation was performed throughout removal of the filling material using a total 5 mL distilled water per canal. The total time required for retreatment (including irrigation) was measured from the time when the canal was entered until no gutta-percha/sealer was visible on the instrument surfaces. The effective operating time was recorded in minutes using a digital chronometer. In addition, if unwinding or instrument separation occurred, it was also recorded.

*Filling removal evaluation*

After retreatment, the SCRC were cross sectioned at 2, 6 and 10 mm from the WL, which were considered as evaluation levels (EL). Sections 1 mm thick were cut at low speed under constant irrigation with distilled water using a diamond wafering blade 0.3 mm thick mounted on a Precision Micro Disc NH-6P cutting machine (DHUC Ing, BA, Argentina). The cuts were made perpendicularly to the long axis of the SCRC (Fig. 1). All sections were photographed under reflected light at x10 magnification using a Sony Cyber-shot DSC-W180 digital camera (Sony Corporation, Tokio, Japan) coupled to an Axio Imager A1m stereomicroscopic loupe (Carl Zeiss, Oberkochen, Germany). The photographs were taken at a fixed focal distance of 5 cm and transferred to a computer. For each SCRC, the area covered by remaining filling material and the total canal area at each of the predetermined levels of the canal were outlined (Fig. 2) and measured

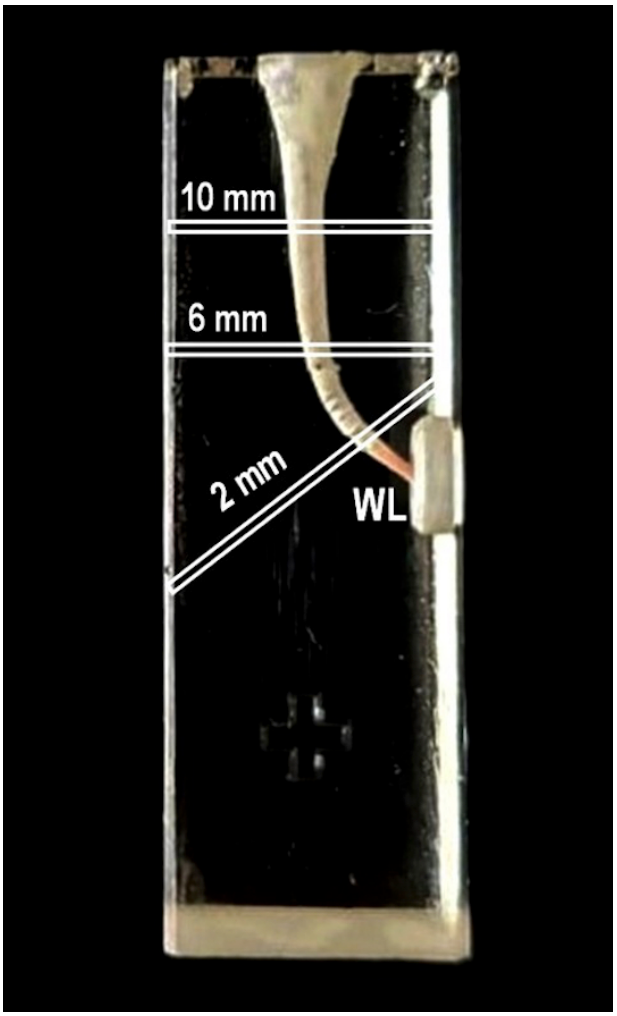


*Fig. 1: Image of a resin block with simulated curved root canal after preparation showing a schematic drawing of the cross sections located at 2, 6 and 10 mm from the WL.*

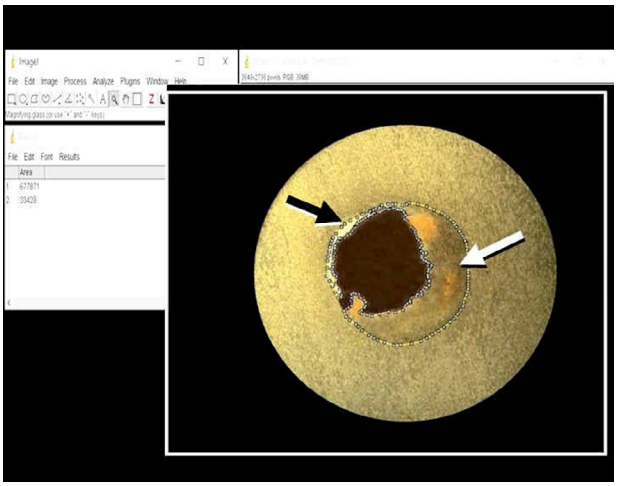

*Fig. 2: Example of gutta-percha and sealer remaining on the root canal walls after retreatment. Note the outlined areas occupied by the materials, calculated using the Image J Program. Black arrow: sealer remnants; White arrow: Gutta-percha remnants. Original magnification X10.*

using the Image J 1.38x Image Analysis Software (National Institutes of Health, Bethesda, MD). The images were analyzed by two trained examiners who were blind to group assignment. Any cases for which there was disagreement were discussed until agreement was reached. Using the digital images, the area of remaining filling material was calculated as percentage. The measurements were repeated 3 times and the mean percentage values for each group were analyzed comparatively.

*Statistical analysis*

The data were analyzed using the SPSS Version 21 (IBM Corp, Chicago IL) at a 5% significance level. To identify any significant differences between groups a Two-way Analysis of Variance for repeated measures was used. The time required by RCPB and PWOG instruments to complete the retreatment procedures was analyzed by Student's *t*-test.

## RESULTS

The mean percentage of remaining filling material and the results for the total time required for retreatment are shown in Table 1. There were significant differences ($p<0.01$) between the two groups with respect to the time required for retreatment (4.6 ± 0.6 and 6.6 ± 1.4 min for RCPB and PWOG, respectively). In both groups, remaining filling material was observed on the canal walls of all specimens. When considering the type of instrument for Retreatment (groups), the RCBP left significantly less filling material than PWOG ($p=0.02$). With respect to the action of the instruments at each EL, there were significant differences among all of them ($p<0.05$). The most significant amount of remaining material in both groups was found at 2 mm from the WL ($p<0.01$). No event of instrument unwinding or separation was noted throughout the experiment.

## DISCUSSION

The success of endodontic retreatment depends on the thorough removal of the old filling material and the elimination of remaining infected tissues that contribute to endodontic failure. The present study compared the capacity of R25 RCPB and PWOG reciprocating instruments for gutta-percha/sealer removal as well as the required operating time for root canal retreatment. For the experiment, resin blocks with standardized SCRC were used in order to avoid any anatomic variations that are normally present in root canals of natural teeth. The degree of homogeneity (baseline) of SCRC with respect to canal volume, surface area and canal length before canal preparation enabled standardization of the groups, thus enhancing the validity of the study[18-22]. However, the results of the study cannot be fullyextrapolated to natural teeth because clinical cases normally involve multiple variables.

In the present study, the matched-taper single gutta-percha cone technique was used for root canal obturation[17]. According to Gordon et al.[23] and Schäfer et al., [24] the tapered cones match the prepared root canal geometry. The technique effectively fills most narrow, curved canals, and has become widely accepted as an equivalent alternative to other obturation techniques[17,24]. As per protocol, the amount of remaining filling material was assessed by cross-sectioning the canals at three different levels. In comparison to other evaluation methods,[7, 11, 25] cross sections allow visualization of the entire circumference of a canal[23], thereby enabling comprehensive assessment of the areas with remaining filling material. Interestingly, no unwinding or instrument separation was observed for RCPB or PWOG during the experiment. Our results agree with those of other authors [15, 16, 26], and suggest that this could be because of the specific heat treatment of the NiTi alloy, which improves instrument resistance to fatigue and flexibility. Moreover, as reported by Ruddle et al.[27], the shape

**Table 1. Means ± SD of remaining filling material (expressed as percentage) at 2, 6 and 10 mm from the WL, and total time required for retreatment.**

| GROUP | n | 2 mm | 6 mm | 10 mm | Time (min) |
|---|---|---|---|---|---|
| 1. RCPB | 10 | $28.5 \pm 8.3^{aA}$ | $18.4 \pm 7.5^{aB}$ | $6.5 \pm 3.2^{aC}$ | $4.6 \pm 0.6^{a}$ |
| 2. PWOG | 10 | $51.3 \pm 28.8^{bA}$ | $22.1 \pm 8.9^{bB}$ | $12.9 \pm 13.3^{bC}$ | $6.6 \pm 1.4^{b}$ |

Different lowercase letters represent significant differences between groups. Different uppercase letters represent significant differences within the same group. SD: Standard deviation

of the cross-section of the RCPB and PWOG appears to provide sufficient space between the flutes and the canal walls to avoid engagement during transportation of debris in coronal direction.

Our findings showed significantly more remaining gutta-percha and sealer at the level of 2 mm from the WL. In this respect, the results are in line with those of Ersev et al.[9] and Khedmat et al.[10], who suggest that similar results could be expected when removing the filling materials with NiTi instruments up to the WL. According to Hülsman and Bluhm[7], this may be because during retreatment, it is difficult, if not impossible, to direct NiTi instruments toward certain aspects of the root canal walls, especially in the apical third. Moreover, the last instruments used for gutta-percha/sealer removal could be insufficient to remove all traces of the filling materials. Because the aim of the present study was limited to experimental comparison of the capacity of RCPB and PWOG for gutta-percha/sealer removal, the effects of further refining the canal walls with larger sized instruments were not tested in our protocol. However, it should be noted that from a clinical point of view, endodontic retreatment procedures require not only removal of filling materials, but also removal of infected dentine. Thus, further re-instrumentation is recommended to ensure better cleaning of the root canal space[28]. The results of this study demonstrated significant differences between RCPB and PWOG with respect to their ability to remove filling material, as well as the total time required for retreatment. Therefore, the null hypothesis was rejected. Our findings agree with other authors [7-10, 26, 29, 30] who report that to date, none of the currently available techniques or instruments are capable of completely removing filling material from root canals. Further research is needed on instruments and retreatment techniques with the aim of identifying which ones are more effective for the removal of pre-existing filling material.

## CONCLUSION

Within the limitations of the present study, RCPB proved to be more capable and faster than PWOG for gutta-percha/sealer removal. Although both instruments were useful and safe, they did not completely remove filling material from laboratory models with simulated curved root canals.

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**DECLARATION OF CONFLICTING INTERESTS**

The authors declare no potential conflicts of interest regarding the research, authorship, and/or publication of this article.

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## REFERENCES

1. Siqueira JF Jr, Rôças IN. Clinical implications and microbiology of bacterial persistence after treatment procedures. J Endod. 2008 Nov;34(11):1291-1301.e3. https://doi.org/10.1016/j.joen.2008.07.028
2. Kvist T, Reit C. Results of endodontic retreatment: a randomized clinical study comparing surgical and nonsurgical procedures. J Endod. 1999 Dec;25(12):814-7. https://doi.org/10.1016/S0099-2399(99)80304-5
3. Gorni FG, Gagliani MM. The outcome of endodontic retreatment: a 2-yr follow-up. J Endod. 2004 Jan;30(1):1-4. https://doi.org/10.1097/00004770-200401000-00001
4. Paik S, Sechrist C, Torabinejad M. Levels of evidence for the outcome of endodontic retreatment. J Endod. 2004 Nov;30(11):745-50. https://doi.org/10.1097/01.don.0000137636.93933.51
5. Schirrmeister JF, Meyer KM, Hermanns P, Altenburger MJ et al. Effectiveness of hand and rotary instrumentation for removing a new synthetic polymer-based root canal obturation material (Epiphany) during retreatment. Int Endod J. 2006 Feb;39(2):150-6. https://doi.org/10.1111/j.1365-2591.2006.01066.x
6. Barrieshi-Nusair KM. Gutta-percha retreatment: effectiveness of nickel-titanium rotary instruments versus stainless steel hand files. J Endod. 2002 Jun;28(6):454-6. https://doi.org/10.1097/00004770-200206000-00009
7. Hülsmann M, Bluhm V. Efficacy, cleaning ability and safety of different rotary NiTi instruments in root canal retreatment. Int Endod J. 2004 Jul;37(7):468-76. https://doi.org/10.1111/j.1365-2591.2004.00823.x
8. Taşdemir T, Er K, Yildirim T, Celik D. Efficacy of three rotary NiTi instruments in removing gutta-percha from root canals. Int Endod J. 2008 Mar;41(3):191-196. https://doi.org/10.1111/j.1365-2591.2007.01335.x
9. Ersev H, Yilmaz B, Dinçol ME, Dağlaroğlu R. The efficacy

of ProTaper Universal rotary retreatment instrumentation to remove single gutta-percha cones cemented with several endodontic sealers. Int Endod J. 2012 Aug;45(8):756-62. https://doi.org/10.1111/j.1365-2591.2012.02032.x
10. Khedmat S, Azari A, Shamshiri AR, Fadae M et al. Efficacy of ProTaper and Mtwo Retreatment Files in Removal of Gutta-percha and GuttaFlow from Root Canals. Iran Endod J. 2016 Summer;11(3):184-7. doi:10.7508/iej.2016.03.007
11. Keskin C, Sarıyılmaz E, Güler DH. Efficacy of novel thermomechanically treated reciprocating systems for gutta-percha removal from root canals obturated with warm vertical compaction. J Dent Res Dent Clin Dent Prospects. 2018 Spring;12(2):110-115. https://doi.org/10.15171/joddd.2018.017
12. Azim AA, Wang HH, Tarrosh M, Azim KA et al. Comparison between Single-file Rotary Systems: Part 1-Efficiency, Effectiveness, and Adverse Effects in Endodontic Retreatment. J Endod. 2018 Nov;44(11):1720-1724. https://doi.org/10.1016/j.joen.2018.07.022
13. Kırıcı D, Demirbuga S, Karataş E. Micro-computed Tomographic Assessment of the Residual Filling Volume, Apical Transportation, and Crack Formation after Retreatment with Reciproc and Reciproc Blue Systems in Curved Root Canals. J Endod. 2020 Feb;46(2):238-243. https://doi.org/10.1016/j.joen.2019.11.003
14. Yared G. Reciproc Blue: The new generation of reciprocation. Gior Ital Endod 2017; 31: 96-101. https://doi.org/10.1016/j.gien.2017.09.003
15. Keskin C, Inan U, Demiral M, Keleş A. Cyclic Fatigue Resistance of Reciproc Blue, Reciproc, and WaveOne Gold Reciprocating Instruments. J Endod. 2017 Aug;43(8):1360-1363. https://doi.org/10.1016/j.joen.2017.03.036
16. Serefoglu B, Miçooğulları Kurt S, Kaval ME, Güneri P et al. Cyclic Fatigue Resistance of Multiused Reciproc Blue Instruments during Retreatment Procedure. J Endod. 2020 Feb;46(2):277-282. https://doi.org/10.1016/j.joen.2019.10.024
17. Hörsted-Bindslev P, Andersen MA, Jensen MF, Nilsson JH et al. Quality of molar root canal fillings performed with the lateral compaction and the single-cone technique. J Endod. 2007 Apr;33(4):468-71. https://doi.org/10.1016/j.joen.2006.12.016
18. Peters OA, Laib A, Göhring TN, Barbakow F. Changes in root canal geometry after preparation assessed by high-resolution computed tomography. J Endod. 2001 Jan;27(1):1-6. https://doi.org/10.1097/00004770-200101000-00001
19. Schäfer E, Florek H. Efficiency of rotary nickel-titanium K3 instruments compared with stainless steel hand K-Flexofile. Part 1. Shaping ability in simulated curved canals. Int Endod J. 2003 Mar;36(3):199-207. https://doi.org/10.1046/j.1365-2591.2003.00643.x
20. Calberson FL, Deroose CA, Hommez GM, De Moor RJ. Shaping ability of ProTaper nickel-titanium files in simulated resin root canals. Int Endod J. 2004 Sep;37(9):613-23. https://doi.org/10.1111/j.1365-2591.2004.00860.x
21. da Silva KT, Grazziotin-Soares R, Limongi O, Irala LE, Salles AA. Wear promoted in the apical third of simulated canals after instrumentation with ProTaper universal system. J Appl Oral Sci. 2009 Sep-Oct;17(5):501-7. https://doi.org/10.1590/S1678-77572009000500027
22. Saleh AM, Vakili Gilani P, Tavanafar S, Schäfer E. Shaping ability of 4 different single-file systems in simulated S-shaped canals. J Endod. 2015 Apr;41(4):548-52. https://doi.org/10.1016/j.joen.2014.11.019
23. Gordon MP, Love RM, Chandler NP. An evaluation of .06 tapered gutta-percha cones for filling of .06 taper prepared curved root canals. Int Endod J. 2005 Feb;38(2):87-96. https://doi.org/10.1111/j.1365-2591.2004.00903.x
24. 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 Jul;39(7):924-8. https://doi.org/10.1016/j.joen.2013.04.001
25. Gu LS, Ling JQ, Wei X, Huang XY. Efficacy of ProTaper Universal rotary retreatment system for gutta-percha removal from root canals. Int Endod J. 2008 Apr;41(4):288-95. https://doi.org/10.1111/j.1365-2591.2007.01350.x
26. Rossi-Fedele G, Ahmed HM. Assessment of Root Canal Filling Removal Effectiveness Using Micro-computed Tomography: A Systematic Review. J Endod. 2017 Apr;43(4):520-526. https://doi.org/10.1016/j.joen.2016.12.008
27. Ruddle CJ, Machtou P, West JD. The shaping movement: fifth-generation technology. Dent Today. 2013 Apr;32(4):94, 96-9. PMID: 23659098.
28. Huang X, Ling J, Wei X, Gu L. Quantitative evaluation of debris extruded apically by using ProTaper Universal Tulsa rotary system in endodontic retreatment. J Endod. 2007 Sep;33(9):1102-5. https://doi.org/10.1016/j.joen.2007.05.019
29. Zmener O, Pameijer CH, Banegas G. Retreatment efficacy of hand versus automated instrumentation in oval-shaped root canals: an ex vivo study. Int Endod J. 2006 Jul;39(7):521-6. https://doi.org/10.1111/j.1365-2591.2006.01100.x
30. Rios Mde A, Villela AM, Cunha RS, Velasco RC et al. Efficacy of 2 reciprocating systems compared with a rotary retreatment system for gutta-percha removal. J Endod. 2014 Apr;40(4):543-6. https://doi.org/10.1016/j.joen.2013.11.013