Effect of ProTaper and Reciproc preparation and gutta-percha cone on cold lateral compaction

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Abstract

Context: The effectiveness of cold lateral compaction depends on the root canal preparation and used gutta-percha cone.

Aims: The aim of this study is to evaluate finger spreader penetration into root canals prepared with ProTaper (PT) or Reciproc (Rec) systems and filled with gutta-percha cones with different tapers.

Materials and Methods: Twenty-four simulated root canals in resin blocks with 30° curvature were prepared up to PT F2 or Rec R25. They were divided into four experimental groups according to the master gutta-percha cone and preparation (25.02 or F2/PT, and 25.02 or R25/Rec). Cold lateral compaction was performed using a stainless steel finger spreader size B. The set cone-finger spreader-resin block was placed in a universal test machine, and a load up to 1.5 kg was applied on the finger spreader. The final distance between the finger spreader and apical preparation after load application was obtained. For comparison among the groups, data were submitted to ANOVA and Tukey’s tests, with a significance level of 5%.

Results: Greater finger spreader penetration was observed for 0.02/Rec and 0.02/PT, followed by F2/PT and R25/Rec.

Conclusion: The use of cones associated with PT and Rec preparations does not allow the finger spreader penetration up to the apical third.

Keywords: Endodontics; gutta-percha; root canal filling materials; root canal obturation

INTRODUCTION

Despite root canal filling techniques that associate gutta-percha to root canal preparation,[1] cold lateral compaction of gutta-percha is one of the most widely used techniques for root canal system filling.[2,3] Although it requires a longer time to perform,[4] the cold lateral compaction technique promotes a thin layer of sealer between the gutta-percha and root canal walls,[5] greater safety as regards the risk of root canal filling extrusion,[6] proper sealing,[7] and sealer penetration into dentinal tubules.[8] The evaluation of root canal filling showed that the spreader penetration was higher using a 0.02 gutta-percha cone than a 0.06 cone.[9]

The use of rotary NiTi systems led to the development of greater taper gutta-percha cones corresponding to the final root canal preparation.[6,9] The single cone technique is easier and faster.[10] However, the lack of standardization of gutta-percha cones[11,12] may result in a thicker layer of sealer between the gutta-percha cone and root canal walls.[13] ProTaper (PT) system provides greater cervical preparation due to its variable taper.[14] The Reciproc (Rec) system with reciprocating kinematic presents a proposal of root canal instrumentation with a single instrument, providing cleanliness and maintenance of root canal trajectory.[15] Both systems have greater taper gutta-percha cones corresponding to the final root canal preparation.[6]

The cold lateral compaction technique using 0.02 ISO standard cones has shown significantly better results regarding percentage of gutta-percha compared to

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techniques using a variable taper single cones (PT, Rec, and WaveOne). Capar et al. compared the quality of filling using single cone, after different rotary system preparations (ProTaper Next, Twisted File Adaptive, OneShape, ProTaper Universal, WaveOne, and Reciproc), in severely curved canals. They verified that the Twisted File Adaptive system showed a lower percentage of gutta-percha filling in the apical third, followed by the Rec system.

To associate the benefits of the cold lateral compaction technique with a shorter working time, the use of greater taper cones associated to the lateral compaction with accessory cones has been proposed. However, the effectiveness of the technique in the apical third depends directly on the finger spreader penetration capacity during lateral compaction.

The present study aimed to evaluate the finger spreader penetration capacity in simulated curved canals prepared with the rotary file system (ProTaper Universal - PT) and reciprocating single-file system (Reciproc – Rec), and filled with standardized gutta-percha master cone tapered 0.02, or standardized greater taper cones of each system.

**MATERIALS AND METHODS**

Gutta-percha cones with taper #25.02 (VDW, Munich, Germany) (n = 12); ProTaper Universal F2 cones (Dentsply-Maillefer, Petrópolis, Rio de Janeiro, Brazil) (n = 6); and Reciproc R25 cones (VDW, Munich, Germany) (n = 6) were used. Each cone was selected by means of measuring the diameters: Apical (D0), at 3 mm (D3) and 16 mm (D16) using a Profile projector (Nikon, Tokyo, Japan). The values of D0, D3, and D16 were used to calculate the taper:

\[
\text{Taper (mm)} = \frac{D3 - D0 (mm)}{\text{Distance between D0 and D3 (mm)}}
\]

Gutta-percha cones with a maximum variation of ±0.02 mm compared to the standard measurement were selected. The diameters D0, D3, and D16 of the stainless steel finger spreader size B were evaluated as used to gutta-percha cones.

**Preparation of resin blocks**

Twenty-four root canals in resin blocks with 30° curvature were prepared with #10 and #15 K-type (Dentsply Maillefer, Ballaigues, Switzerland) stainless steel files throughout the extension of the root canal. After this, 12 blocks were prepared using ProTaper Universal System (Dentsply-Maillefer) following the sequence SX, S1, S2, F1, and F2. X-Smart rotary system (Dentsply-Maillefer), at a speed of 250 rpm and torque of 1 N, was used for root canal preparation. The other 12 blocks were prepared with the Rec system (VDW) using R25. VDW Silver Reciproc Motor (VDW, Munich, Germany) was used according to the manufacturer’s instructions.

Root canals were irrigated with 5 ml of 1% sodium hypochlorite, at each change of instrument. Irrigation was performed with 30-gauge NaviTips (Ultradent Products, Inc., South Jordan, UT, USA) and 5 mL syringes (Ultradent Products, South Jordan, UT, USA). After final irrigation, the resin blocks were dried with absorbent paper cones, and randomly divided into 4 experimental groups (n = 6) according to the system and cones used:

- PT system – gutta-percha cone #25.02
- PT system – gutta-percha cone F2
- Rec system – gutta-percha cone #25.02
- Rec system – gutta-percha cone R25.

**Evaluation of the finger spreader linear penetration**

In all groups, cold lateral compaction was performed using a stainless steel finger spreader B (Dentsply-Maillefer). An apparatus, especially developed for the experiment, was used. It is composed by a base in which simulated root canal/gutta-percha cone/finger spreader were fitted and adapted to a universal testing machine. The cone was introduced into the instrumented resin block until its adjustment in the preparation length. The finger spreader was laterally and passively introduced beside the cone. The initial finger spreader penetration was obtained using a digital paquimeter. After that, the apparatus was placed in the universal testing machine, EMIC DL 2000 (EMIC Equipamentos e Sistemas de Ensaios, São José dos Pinhais, Paraná, Brazil) [Figure 1], with a load cell of 500 N at a speed of 5 cm/min. Loads with 0.5, 1, and 1.5 kg of force were applied on the finger spreader. At the end of each cycle, the distance between the apical limit of the simulated canal and the final portion of finger spreader was obtained.

![Figure 1: Apparatus in which simulated root canal /gutta-percha cone/finger spreader was adapted to a universal test machine. A- Distance measured between finger spreader and total root canal length](image-url)
Statistical analysis
The data were submitted to the ANOVA and Tukey post hoc test at a level of significance of 5%.

RESULTS
Statistical analysis of the data showed statistically significant difference among all the groups \((P < 0.05)\), with greater penetration being observed in the groups 0.02/Rec and 0.02/PT, followed by groups F2/PT and R25/Rec, as shown in Table 1.

In the comparison among the different forces applied on the finger spreader, the greatest penetration was observed when the 1.5 kg load was used in all groups. The results were different from other loads, except to 1.0 and 1.5 kg in Group 0.02/PT, as shown in Table 2.

DISCUSSION
Tridimensional filling of the root canal is essential to prevent reinfection of the root canal system.\(^4\) The apical third is the most important portion for evaluating the quality of root canal fillings\(^{10,17}\) due to anatomical variability and the presence of ramifications\(^18\), which may harbor microorganisms related to treatment failures.\(^19\)

Therefore, adequate sealing of the apical third contributes to the success of endodontic therapy.\(^20\)

Root canal with simulated curvature in resin blocks has been used for root canal transportation analysis using different preparation methods\(^{21}\) and root canal filling techniques.\(^{1,12}\) This method enables standardization of root canal preparation. In the present study, the effectiveness of cold lateral compaction in the apical third was evaluated by means of the finger spreader penetration capacity, under the effect of different loads, in simulated root canals with curvature. According to Harvey et al.,\(^{23}\) the mean load used by endodontists during cold lateral compaction is between 1.0 and 3.0 kg. Holcomb et al.\(^{24}\) reported that vertical root fractures do not occur in mandibular incisors using spreader load smaller than 1.5 kg. This value was used in the present study as a parameter to limit the load used during cold lateral compaction.

In root canals with curvatures, the use of master cones with greater taper may make difficult the finger spreader penetration.\(^{25}\) However, studies that evaluated the root canal filling quality using the cold lateral compaction technique and master cones with standard 0.02 or greater taper showed controversial results as regards the percentage of gutta-percha-filled areas, sealer-filled areas, and voids, or bacterial leakage.\(^{9,10,16,26}\)

Comparing the cold lateral compaction technique using cones with a standard taper (0.02) and greater taper gutta-percha cones compatible with the final root canal preparation, no significant differences were observed, regarding bacterial leakage,\(^{9,16}\) and percentage of gutta-percha–filled areas, sealer-filled areas, and voids, in straight root canals.\(^{16}\) Similarly, Schäfer et al.\(^{16}\) reported that the cold lateral compaction technique with standardized gutta-percha master cone tapered 0.02, or greater taper cones in severely curved canals obtained the same results as regards the percentage of gutta-percha-filled areas, sealer-filled areas, and voids.

However, Schäfer et al.\(^{16}\) used a gutta-percha master cone taper 0.04, which does not correspond to the final root canal preparation taper (0.06). This possibly favored the penetration of the finger spreader into the apical third, justifying the similar results regarding the quality of filling using 0.04 and 0.02 cones.

In the present study, the greater finger spreader penetration was observed using standardized 0.02 cones (between 0.8 and 1.6 mm from apex). The associations F2/PT and R25/Rec made it impossible for the finger spreader penetration up to the apical third (between 4 and 6 mm from apical preparation). These results may be attributed to the greater taper presented by F2 PT and R25 Rec cones. They presented a 0.25 mm tip and 0.08 taper in the apical 3 mm, preventing finger spreader penetration into the apical third of curved canals. Therefore, the greater taper presented by the F2 PT and R25 Rec decreased the space

Table 1: Distance (mm) between finger spreader and working length

| Conditions | 0.02/PT | F2/PT | 0.02/Rec | R25/Rec |
|------------|---------|-------|----------|---------|
| Mean       | 1.720\(a\) | 4.215\(b\) | 0.8000\(c\) | 6.465\(c\) |
| SD         | ±0.4550 | ±0.4373 | ±0.1992 | ±0.7728 |

\(^{a,b,c}\)Different letters in the same line indicate statistically significant difference among groups (\(P < 0.05\)). PT: ProTaper, Rec: Reciproc, SD: Standard deviation

Table 2: Distance (mm) between the finger spreader and working length considering different applied loads

| Conditions | 0.5 kg | 1 kg | 1.5 kg |
|------------|-------|------|--------|
| 0.02/PT    |       |      |        |
| Mean       | 2.483\(a\) | 1.837\(h\) | 1.665\(b\) |
| SD         | ±0.3821 | ±0.5001 | ±0.4604 |
| F2/PT      |       |      |        |
| Mean       | 6.747\(h\) | 5.077\(h\) | 4.215\(a\) |
| SD         | ±0.4136 | ±0.6365 | ±0.04373 |
| 0.02/Rec   |       |      |        |
| Mean       | 2.540\(c\) | 1.587\(c\) | 0.8000\(c\) |
| SD         | ±0.5930 | ±0.6323 | ±0.1992 |
| R25/Rec    |       |      |        |
| Mean       | 9.897\(c\) | 8.028\(c\) | 6.465\(c\) |
| SD         | ±0.4481 | ±0.6855 | ±0.7728 |

\(^{a,b,c}\)Different letters on the same line indicate statistically significant difference (\(P < 0.05\)). PT: ProTaper, Rec: Reciproc, SD: Standard deviation
in the apical third and prevented the linear finger spreader displacement in this region.

The present study revealed that the use of greater taper cones corresponding to the final root canal preparation, associated with cold lateral compaction, does not promote any improvement in the root canals filling at the apical third, in agreement with other studies. Ozawa et al. pointed out that no benefit was observed with the use of the cold lateral compaction technique with master cones with greater tapers (0.06). Accessory cones rarely reach the apical third due to the smaller available space. Wilson and Baumgartner observed that greater penetration of the finger spreader was possible in root canals filled with standardized master cone taper 0.02 in comparison with the other tapers.

Pérez Heredia et al. evaluated the quality of apical sealing. They compared the low-temperature thermoplasticated gutta-percha and cold lateral compaction technique using a 0.06 or a 0.02 mm/mm taper gutta-percha master cone. Although no statistically significant differences as regards apical leakage were observed among the three techniques evaluated, the mean leakage was lower for the root canals filled with standardized taper 0.02, in comparison with cones of taper 0.06. This difference was attributed to the greater penetration of the finger spreader when master cone 0.02 was used.

CONCLUSION

Based on the obtained results, the use of gutta-percha cones with taper corresponding to PT and Rec preparations prevents the finger spreader penetration up to the apical third. Cold lateral compaction in the apical third may be performed after PT and Rec preparations using 0.02 gutta-percha cones.

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Conflicts of interest

There are no conflicts of interest.

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