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Effectiveness of different gutta-percha techniques when filling experimental internal resorptive cavities

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Abstract

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Aim To determine the quality of root fillings in teeth with artificial internal resorptive cavities filled with Thermafil, JS Quick-Fill, Soft Core, System B and Microseal, and by cold lateral compaction (LC) technique.

Methodology Sixty maxillary incisor teeth were selected. After access cavity preparation and root canal instrumentation, the roots were sectioned horizontally and artificial internal resorption cavities were prepared on the canal walls. The tooth sections were cemented together and the root canals were filled using one of six different techniques: Thermafil, JS Quick-Fill, Soft Core, System B and Microseal, and by LC. The roots were then divided at the level of the previous section and each root surface was photographed. Image analysis program was used to calculate the percentage of sealer, gutta-percha and void in the internal resorptive cavities. All measurements were analysed statistically using One-way ANOVA and Newman–Keuls tests.

Results The Microseal technique filled 99% of the artificial resorptive area followed by LC (92%), SystemB (89%), Quick-Fill (88%), Thermafil (74%) and Soft-Core (73%). Warm gutta-percha compaction techniques filled the resorption areas with more gutta-percha than sealer (Microseal 68%, System B 62%) compared to the other techniques (LC 48%, Quick Fill 41%, Soft Core 34%, Thermafil 35%). In addition, core techniques left a considerable volume of voids in the resorptive areas (Quick-Fill 12%, Thermafil 26%, Soft Core 27%).

Conclusions Warm gutta techniques filled artificial resorption cavities significantly better than the other gutta-percha techniques.

Keywords: internal resorption, JS Quick-Fill, Microseal, Soft Core, System B, Thermafil.

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Introduction

Complete filling of the root canal with an inert filling material has been proposed as one of the goals of root canal treatment (Nyguen 1984). Root canal anatomy may display complex irregularities in shape as a result of pathological processes such as internal resorption. These irregularities cannot usually be reached by root canal instruments and this leads to some difficulties during cleaning, shaping and filling of the root canal (Nyguen 1984).

Many techniques and materials have been studied *ex vivo* as possibilities to fill internal resorptive defects (Gutmann *et al.* 1993, Agarwal *et al.* 2002, Collins *et al.* 2006). Gutmann *et al.* (1993) suggested the use of the Thermafil obturation technique; whilst Agarwal *et al.* (2002) reported that the use of ultrasonics to condense the gutta-percha and the Obtura II system were superior to the Thermafil and lateral compaction (LC) techniques. Collins *et al.* (2006) suggested the use of warm lateral and warm vertical condensation gutta-percha techniques for such cases. Radiographic evaluation to assess voids is limited and it is difficult to

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differentiate gutta-percha and sealer, even with the advent of digital radiographic systems.

The objective of this study was to investigate the quality of root fillings by measuring the sealer/core/voids ratios of artificial internal resorptive areas of root canals filled with the thermo-mechanical (JS Quick-Fill) and thermo-plasticized (Thermafil, Soft Core) gutta-percha core techniques, a warm vertical condensation technique (System B), a warm lateral condensation technique (Microseal) or cold LC technique.

Materials and methods

Sixty maxillary central incisor teeth were selected and adjusted to a length of 20 mm. A conventional endodontic access was prepared in each tooth and a size 10-K file was inserted to determine the location of the apical foramen. The teeth were instrumented to master apical file, size 60, using the step-back technique combined with 2.5% sodium hypochlorite irrigation.

To create artificial internal resorptive cavities, the roots were sectioned horizontally with a fine diamond disc 7 mm from the apex. Semi-circular cavities were created using a low speed No. 6 round diamond bur around the periphery of the opening of the root canal of each section (Andreasen *et al.* 1987, Goldberg *et al.* 2000). Then the sections were cemented together using Peligom glue (Pelikan cyanoacrylate adhesive; Istanbul, Turkey) on the dentine surface around the cavities (Fig. 1). Each tooth was embedded in a plaster cast. Then, sixty teeth were randomly assigned to six groups of ten.

Group 1: lateral compaction

A gutta-percha master cone was fitted within 0.5 mm of the working length. Freshly mixed pulp canal sealer (Kerr, Romulus, MI, USA) was applied to the root canal walls using a file in a counter-clockwise rotation. The master cone was lightly coated with sealer and placed into the root canal. LC was achieved using standardized finger spreaders (Dentsply Maillefer, Ballaigues, Switzerland). When the points prevented the spreader penetrating beyond the coronal third of the canal, the canal was considered to be adequately filled and excess gutta-percha was removed with a hot instrument.

Group 2: warm vertical compaction with System B

In the second group, a System B obturator (EIE/Analytic Technology, Richmond, WA, USA) was used to compact gutta-percha as recommended by the manufacturer. Sealer was applied to the canal walls with a file and then the selected gutta-percha cone was placed within 0.5 mm of the working length. A medium large insert tip, which bounds in the canal 3 mm from the working length, was used to condense the gutta-percha. The System B unit was preset to 200 °C during the apical condensation of the primary cone (downpack), and to 100 °C when adapting and condensing the apical portion of the secondary gutta-percha cone, and finally to 250 °C to soften the rest of the secondary cone prior to vertical condensation (Silver *et al.* 1999).

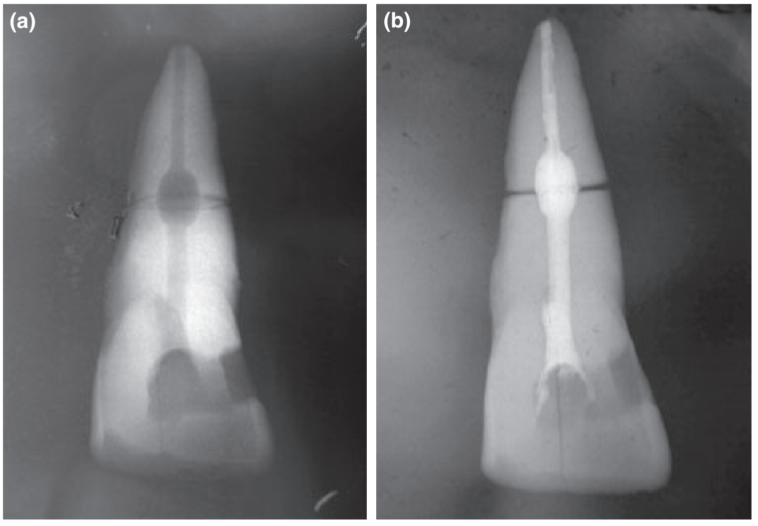

Figure 1 (a,b) Radiographic appearance of simulated resorptive cavity. Radiograph of root filling specimen.

Group 3: Microseal system

In the third group, root canals were filled using the Microseal system. An appropriate sized master cone was selected to achieve tug back. The appropriate spreader was selected to compact the gutta-percha master cone within 1.0 mm of the working length. Finally, the appropriate mechanical compactors were selected according to the manufacturer's instruction. Sealer (Kerr) was applied to the canal walls using a file and the master gutta-percha cone coated in sealer was positioned. Then the spreader was inserted alongside the master cone at the appropriate length for compaction. Upon withdrawal of the spreader from the canal, a tapered void was formed between the compacted gutta-percha cone and the root canal walls. The appropriate compactor was inserted in the heated gutta-percha cartridge and was coated with a uniform layer of material. The gutta-percha-coated compactor was then immediately placed in the void, and placed as close to the working length as possible, avoiding rotation whilst being inserted. Whilst resisting the backing-out motion, but without using apical pressure, the rotation of the compactor was initiated at a speed of 6000 rpm. After approximately 2 s, the compactor was removed slowly, whilst being gently pushed against one side of the canal. Rotation did not stop until the compactor was removed fully from the canal. If the canal was not completely filled, more gutta-percha was placed on the compactor. That is, the process continued until the canal was perceived to be completely filled. Then, excess gutta-percha and sealer were removed from the access cavity (Korzen 1997).

Group 4: Thermafil obturation

The canals were filled using the metal carrier Thermafil system (Dentsply Maillefer). Sealer (Kerr) was applied to the canal walls with a file and a size 60 Thermafil obturator was warmed in a Thermaprep oven (Therma Prep Plus, Dentsply Maillefer, Ballaigues, Switzerland) for a minimum of 10 s in accordance with the manufacturer's recommendations. The heated obturator was slowly inserted into the canal within 0.5 mm of the working length. An inverted cone bur was used to cut through the shank of each carrier.

Group 5: JS Quick-Fill

JS Quick-Fill obturators (JS Dental Manufacturing Inc, Ridgefeild, CT, USA) were used in accordance with the manufacturer's instructions. Sealer (Kerr) was applied to the canal walls with a file and a size 50 Quick-Fill obturator (two sizes smaller than the last file used to prepare the apical third of the canal) was lightly coated with the sealer and positioned in the canal until a slight resistance was felt. Rotation was used until plasticity of gutta-percha was observed, and slight pressure was applied apically until it reached working length and then the obturator was left in the canal. Then, an inverted cone bur was used to cut through the shank of each carrier.

Group 6: Soft Core

Based on the information obtained from a 'size verifier', a size 60 Soft-Core obturator was selected and heated. Sealer (Kerr) was applied to the canal walls using a file and the plasticized Soft-Core device was inserted to the apical stop. After the filling was completed, the handle and insertion pin were removed, and the excess plastic core was removed with a small inverted cone bur (Soft Core® Manual, Copenhagen, Denmark).

Following filling, the teeth were stored for 7 days at room temperature to ensure all materials had set. The plaster cast was removed and radiographs of the teeth were taken (Fig. 1). Then, each tooth was sectioned with a rotary saw 7 mm from the apex at the level of the previous cut, and under cold water to minimize gutta-percha smearing.

Photographs of both surfaces of the sectioned area were taken by using a Nikon Coolpix 885 digital camera (Nikon Imaging Japan Inc., Tokyo, Japan), which was mounted on a stereomicroscope ocular eye

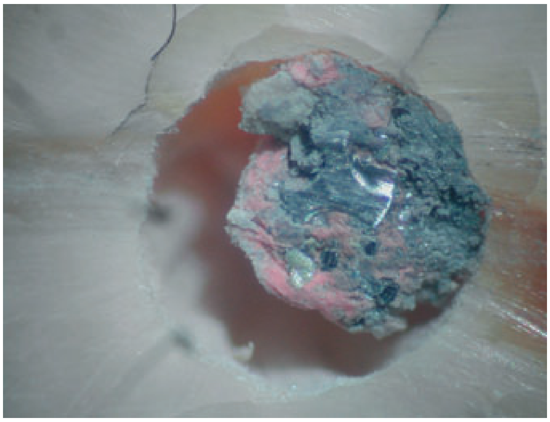

Figure 2 Photograph of tooth sectioned at the middle of the simulated internal resorptive cavity and filled using the Thermafil obturation technique.

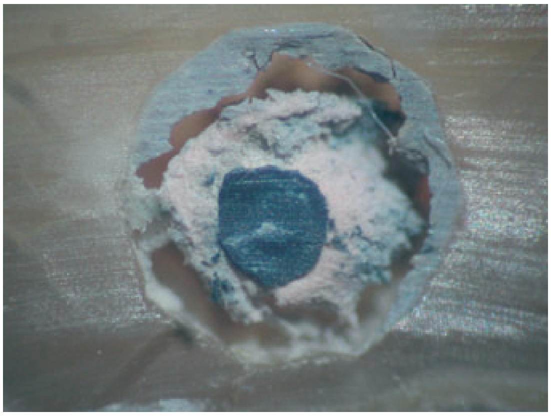

Figure 3 Photograph of tooth sectioned at the middle of the simulated internal resorptive cavity and filled using the Soft Core obturation technique.

Figure 5 Photograph of tooth sectioned at the middle of the simulated internal resorptive cavity and filled using the lateral compaction technique.

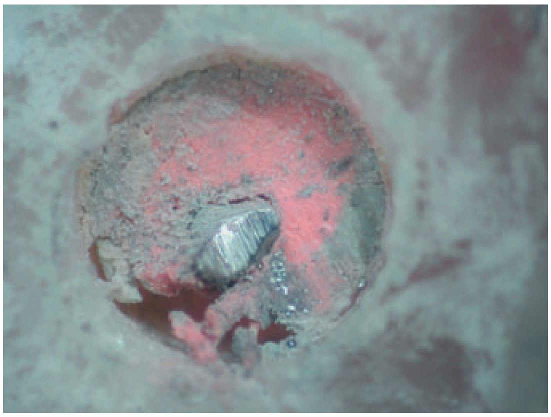

Figure 4 Photograph of tooth sectioned at the middle of the simulated internal resorptive cavity and filled using the JS Quick-Fill obturation technique.

Figure 6 Photograph of tooth sectioned at the middle of the simulated internal resorptive cavity and filled using the Microseal obturation technique.

(Fig. 2–7). The photographs were transferred to a computer and an image analysis program (IMAGE-PRO® PLUS; Media Cybernetics, Inc., Silver Spring, MD, USA) was used to calculate the percentage of sealer, gutta-percha and voids. In the Thermafil, JS Quick-Fill and Soft-Core specimens, metal or plastic carriers were regarded as gutta-percha whilst calculating the ratio of sealer, gutta-percha and voids (Gencoglu *et al.* 2002, Gencoglu 2003). Whilst filling procedures were performed by one individual, the evaluations were performed independently by someone blinded with respect to the experimental group. All measurements were statistically analysed by using One-way ANOVA and Newman–Keuls tests.

Results

Percentages of artificial resorptive area filled by gutta-percha, sealer or voids are given in Table 1.

Total filled area

Statistical analyses revealed that the warm lateral condensation technique (Microseal) was associated with the greatest total filled area (gutta-percha and sealer) ($P < 0.05$). Warm lateral (Microseal) and vertical (System B) condensation techniques had more gutta-percha and sealer content than core techniques ($P < 0.05$). Cold LC had more gutta-percha and sealer content than core techniques ($P > 0.05$).

Figure 7 Photograph of tooth sectioned at the middle of the simulated internal resorptive cavity and filled using the System B obturation technique.

Gutta-percha area

When the proportion of gutta-percha in the artificial resorptive areas were analysed, Microseal had a statistically greater proportion of gutta-percha than other techniques ($P < 0.05$), except for System B. System B had a great proportion of gutta-percha than core techniques (Thermafil, Quick-Fill and Soft-Core) ($P < 0.05$); cold LC also contained more gutta-percha than Thermafil and Soft-Core techniques ($P < 0.05$).

When the gutta and sealer ratios were compared, all condensation techniques (Microseal, System B and LC) had more gutta-percha than sealer. However, all core techniques (Thermafil, Soft-Core, Quick-Fill) had more sealer than gutta-percha.

Voids

When the area of voids was compared, Microseal had the lowest proportion of voids ($P < 0.05$) followed by LC and System B. Core techniques had more voids than the other techniques. Amongst the core techniques, Quick-Fill had more gutta-percha and less voids content than the Thermafil and Soft-Core techniques.

Discussion

The objective of filling a root canal is to provide an environment that prevents growth of residual bacteria and inhibits the introduction of new bacteria. However, there is little data available on whether any particular technique is superior for filling canals with resorptive defects.

In previous studies, radiographic methods were used to analyse the filling of resorptive areas. Both Stamos & Stamos (1986) and Wilson & Barnes (1987) reported excellent results radiographically when using the Obtura system combined with vertical compaction in the filling of root canals with internal resorptive cavities. However, Goldberg *et al.* (2000) stated that the buccolingual radiograph was limited for documenting filling of defects; they claimed that adding a mesiodistally directed radiograph is more useful for this purpose. As it is difficult to assess voids and almost impossible to differentiate gutta-percha and sealer radiographically, radiographic evaluation is inadequate for evaluating the quality of root filling for internal resorptive cavities.

In the present study, an image analysis program (IMAGE-PRO PLUS 4.5) was used to evaluate the quality of the root filling by calculating the percentage of gutta-percha, sealer or voids. The warm lateral condensation technique, Microseal, resulted in the few voids whereas the thermoplasticized core techniques were ineffective in filling the resorptive area with gutta-percha. However, it must be remembered that no vertical condensation was included in the core technique, a technique that could have compacted gutta-percha into the resorptive cavities more than using the passive technique used in the present study.

It is generally accepted (Peters 1986, Wesselink 1990, Miserendino 1991, Kontakiotis *et al.* 1997, Gencoglu *et al.* 2002, Gencoglu 2003) that root fillings should contain more gutta-percha and less sealer. This may be more important when filling root canals with resorptive lacunas. In resorptive lacunas, it is difficult to remove all bacteria and their products from the

Table 1 Percentages of canal area filled with gutta-percha/sealer by filling technique

Technique	GP + Sealer	Gutta-percha	Sealer	Voids
Mean(%) ± SD				
Microseal	98.59 ± 3.58	67.98 ± 11.11	30.60 ± 11.39	1.27 ± 3.55
Lateral compaction	91.55 ± 10.20	47.54 ± 10.89	44.01 ± 14.13	8.45 ± 10.52
System B	89.17 ± 13.02	62.05 ± 9.32	27.12 ± 9.39	10.82 ± 4.65
Quick-Fill	87.91 ± 11.31	41.39 ± 10.48	47.85 ± 16.62	12.09 ± 11.31
Thermafil	74.36 ± 17.92	34.30 ± 10.09	40.06 ± 14.09	25.67 ± 18.60
Soft Core	73.21 ± 23.78	35.47 ± 8.01	37.73 ± 21.45	26.79 ± 23.78

dentinal tubules. Dense compacted gutta-percha may block dentinal tubules, and this may lead to better entombment of microorganisms.

Gencoglu (2003) found that core techniques contained more gutta-percha than warm condensation (Microseal), vertical condensation (System B) and cold lateral condensation techniques when filling regular root canals. Wilson & Barnes (1987) reported that thermoplasticized gutta-percha techniques were acceptable for filling of internal resorption cavities in a case report. In addition, Gutmann *et al.* (1993) concluded that the use of Thermafil obturation technique *ex vivo* was acceptable. However, these results were not confirmed in the present study with regard to filling internal resorptive cavities. Goldberg *et al.* (2000) and Agarwal *et al.* (2002) also reported that the Thermafil technique did not fill resorptive cavities. Indeed, in the present study, all core techniques (Thermafil, Quick-Fill, Soft-Core) were less effective for filling resorptive cavities, whereas both Microseal and System B filled the resorptive cavities to a greater extent than core techniques, mainly with gutta-percha. In addition, all core techniques had more voids than the condensation techniques.

JS Quick-Fill is a mechanically thermoplasticized (thermomechanic) gutta-percha filling method in which a titanium carrier is covered with gutta-percha. Rotation of the carrier within the root canal generates frictional heat, and the plasticized gutta-percha is moved apically. Rotation of the carrier within the root canal and heat may increase the amount of gutta-percha in the resorptive area. But it appeared that warmed gutta-percha around the core material was not adequate in filling the hollow space in the resorbtive area. In each core technique, the amount of gutta-percha surrounding the core material and the characteristics of fluidity is different and this may affect the filling quality of the core techniques in resorbtive area.

All condensation techniques were found to be more successful than core techniques in the filling of resorptive cavities. Amongst the condensation techniques, Microseal was observed to be the most successful in comparison with System B and LC. Using the Microseal technique prevented voids and produced more homogenous gutta-percha content in the artificial resorptive area; System B and LC techniques revealed similar results (System B 89%, LC (92%). Whilst the resorption area was extensively filled with gutta-percha in the System B technique, the sealer proportion in resorption areas was 27%. However, in the LC technique, the sealer proportion in the resorption area was 48%. This high sealer proportion in LC is associated with inability of cold gutta-percha cones to be compacted into the cavities and the diffusion of the sealer into the resorption area during condensation.

Conclusions

The Microseal technique filled artificial resorptive cavities better than other gutta-percha techniques.

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