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An *in vitro* investigation of coronal leakage with three gutta-percha backfilling techniques

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Summary

The aim of this study was to compare the backfilling capabilities of System B, Obtura II and Alphaseal. Forty-six lower premolar teeth were prepared chemomechanically and allocated to four experimental and two control groups. Ten were obturated using lateral condensation as a standard and 30 were obturated in the apical third using the System B. The latter 30 teeth were then backfilled using one of three techniques, System B, Obtura II or Alphaseal ($n = 10$ in each group). The remaining six teeth served as controls. Roots were radiographed from the proximal in order to evaluate voids and then placed in India ink for 65 h prior to being demineralized and rendered transparent, coronal leakage was quantified by linear measurement of ink penetration. No significant difference was found between the four groups with respect to the presence of voids radiographically ($P < 0.05$). The difference in leakage between the System B and Obtura II groups was not significant ($P > 0.05$). Both System B and Obtura II leaked significantly less than Alphaseal and lateral condensation ($P < 0.001$).

Keywords: **Alphaseal, leakage, Obtura, obturation, System B.**

Introduction

Coronal leakage is an important cause of failure in root-canal treatment (Saunders & Saunders 1994). It has been shown *in vitro* (Swanson & Madison 1987) that canals with apparently sound root fillings demonstrate marked coronal leakage after exposure to artificial saliva. Similar findings have been reported (Torabinejad *et al.* 1990, Khayat *et al.* 1993) in that root-filled teeth exposed to bacteria coronally have been shown to be contaminated apically.

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Obturation of the root canal system forms the final stage of root canal therapy and its success depends on thorough cleaning and shaping of the canal system (Schilder 1974). The aim of obturation is to provide a three-dimensional seal of the root canal space. Several techniques have been developed in order to achieve this. These include cold lateral condensation (Grossman 1981), thermomechanical compaction (McSpadden 1980), Thermafil (Johnson 1978), thermoplasticized gutta percha (Gutmann & Rakusin 1987) and vertical condensation (Schilder 1967). The initial phase of vertical condensation is termed the 'downpack' and aims to seal the apical few millimetres of the canal system. The 'downpack' does, however, leave empty canal space coronally and it is the obturation of this space that is termed 'backfilling'.

Lateral condensation can be performed cold (Grossman 1981), warm (Martin & Fischer 1990) or in conjunction with thermomechanical compaction as a hybrid technique (Tagger 1984). This versatile technique has thus become one of the most frequently used obturation methods. Thermafil (Johnson 1978), a carrier-based technique has been shown to be a quick and effective means of obturating the root canal system (Gutmann *et al.* 1993, Dummer *et al.* 1994, Felstead *et al.* 1994). The original technique of vertical condensation was time consuming, it was however, developed further with the introduction of the 'Touch and Heat' (Analytic Technology, Redmont, WA, USA). This instrument allowed a heat carrier to be heated electrically instead of in a flame, thus vertical condensation could be carried out more easily and predictably as there was greater control over the length of time the heat could be applied. The temperature of the heat carrier, however, continued to rise for as long as it was activated.

Recently a new technique, 'the continuous wave of obturation' has been introduced and it is said to simplify and speed up vertical condensation of the root canal system (Buchanan 1994). This technique uses a new device, the System B (Analytic Technology, Redmont,

WA, USA). The System B has four interchangeable pluggers, fine, fine-medium, medium and medium-large, which, it is claimed, can be heated to preset temperatures prior to vertically condensing the gutta percha within the root canal system. The appropriate plugger is selected to match the taper of the master cone and is then used to condense the gutta percha to within 5 mm of the terminus of the root canal. The remaining canal space requires backfilling if a post space is not required, otherwise coronal leakage would result, probably leading to failure of the root canal treatment (Saunders & Saunders 1994). This backfilling is frequently performed using the Obtura II (Obtura Corp., Fenton, MO, USA) to introduce small pieces of thermoplasticized gutta percha to the root canal, which are then condensed using hand instruments. A new backfilling technique has now been developed using the System B (Buchanan 1994) but has not been investigated.

A further development of canal obturation has been the introduction of Alphaseal (Multi-Phase I & II; NiTi Co., Chattanooga, TN, USA). This consists of high viscosity Multi-Phase I and low viscosity Multi-Phase II gutta-perchas which are introduced to the canal system by means of a rotary nickel titanium condenser. Recently a new condenser has been introduced, the Pacmac 25.04 taper (NiTi Co.), which is said to be more effective in introducing gutta-percha into the orifice of the canal (McSpadden 1995). This technique may be used for backfilling but is modified in that only the Multi-Phase II is used.

The aim of this study was to evaluate three different methods of backfilling; the System B, Obtura II and Alphaseal.

Materials and methods

Forty-six single-rooted, lower premolar teeth of similar size with mature root apices were cleaned of attached debris with a sharp knife and stored in a 3% sodium hypochlorite solution. The teeth were radiographed in two planes to ensure a single main root canal that appeared oval in cross-section. All canal preparation and obturation was performed by the same author (AMcR) after extensive practice. Access to the pulp chamber was gained using a water-cooled, high speed diamond bur and the coronal portion of the root canal flared using Gates Glidden drills sizes 110, 090, 070 (Maillefer, Ballaigues, Switzerland) to provide straight line access. Irrigation was performed using 3% sodium hypochlorite delivered into the canals via a syringe with a 27-gauge needle (Monoject; Sherwood Medical, St Louis, MO, USA). All teeth were then sectioned at the amelocemental junction leaving the full root length. A size 10 file was placed in the root canal until the tip could be seen at the apical constriction, this length was recorded and the working length chosen as 1 mm shorter. The apical portion of the canals were prepared with Profile NiTi rotary files 0.04 taper series (Tulsa Dental Products, Tulsa, OK, USA) 2–7 at 200 r.p.m. in an ultraslow handpiece (Maillefer, Ballaigues, Switzerland) according to the manufacturers instructions. The preparation was completed with a Profile 0.06 taper size 7 at 150 r.p.m. At the end of preparation the canals remained oval in the coronal third.

The teeth were allocated randomly to four experimental groups of 10 teeth each. Three of the groups were obturated in the apical third using the System B and backfilled using one of three different techniques System B, Obtura II or Alphaseal in accordance with the manufacturers' instructions. The fourth group was obturated using lateral condensation throughout the whole canal. Sealer (Topseal, Maillefer, Ballaigues, Switzerland) was used in all groups for apical third obturation and backfilling. The remaining teeth were used as controls ($n = 3$ in both groups).

The apical third obturation with the System B was performed as follows. A size medium master gutta-percha cone was selected which gave 'tug back' in the apical 1 mm of the root canal preparation. The medium System B plugger was selected and marked at its binding point with a rubber stopper, which was within 4–6 mm of the working length. A small bead of sealer was carried into the dry canal with a size 35 file and gently worked up and down in small strokes to smear the sealer cement along the canal walls. The master cone was lightly coated with sealer on the apical third only and placed to length in the canal, one or two additional cones (size fine-medium) were placed to ensure adequate gutta-percha was present to enable a centred downpack through the oval canal system.

The System B was set at 200°C (power setting 10), the heated plugger activated and packed down through the gutta-percha to 3 mm short of the binding point (this procedure took approximately 1–2 s). The plugger was then deactivated but the apical pressure maintained for 8–10 s to counter shrinkage of the cooling gutta-percha. The heat was then activated for 0.5 s with apical pressure, which allowed the plugger to drop to its binding point. The plugger was swiftly rotated and removed, bringing with it the excess coronal gutta percha. A hand-held plugger (No. 1/1; Maillefer,

Ballaigues, Switzerland) was immediately used around the perimeter of the canal using short, firm, vertical strokes circumferentially to pack the apical plug. A sustained final push was then given to the centre of the filling material. Apical plugs were created for 30 experimental teeth which were randomly divided into three groups of 10 for backfilling using the System B, Obtura II or Alphaseal.

1 System B: a backfilling gutta-percha point corresponding to the size of the master cone was selected and trimmed until 'tug back' was achieved. Additional points (fine-medium) were placed laterally in view of the oval shape of the canals. The System B plugger was reintroduced at a reduced temperature of 100°C, activated for 1 s and placed to half its previous depth in the canal, the backfilling points were stabilized as necessary and the System B plugger removed. The temperature setting was increased to 250°C, the coronal gutta-percha heated for 1–2 s and condensed using a hand plugger (No. 2/4, Maillefer, Ballaigues, Switzerland) until it was flush with the root face.

2 Obtura II: the temperature control of the Obtura II unit was set to 100% heat and a 23-gauge needle used to deliver thermosoftened gutta-percha to the root canal system. This was introduced in three stages and condensed using hand pluggers of increasing size (Nos 1/2, 2/3, 2/4, Maillefer, Ballaigues, Switzerland) circumferentially and centrally in the canal until it was filled flush with the sectioned root.

3 Alphaseal: the teeth in this group were backfilled using a Pacmac size 25.04 taper NiTi condenser (NiTi Co, Chattanooga, TN, USA) at 5000 r.p.m. The condenser was coated with Multi-Phase II gutta-percha, inserted into the canal and the handpiece activated with the condenser held in position for 1–2 s prior to withdrawal favouring one wall of the canal. Excess gutta-percha after it had cooled was cut off from the top of the sectioned root using a scalpel.

4 Lateral condensation: the canal was dried thoroughly and a master gutta-percha cone (Kerr, Peterborough, UK) was chosen and trimmed appropriately so that it passed down the canal to the working length and showed resistance to removal or 'tug back'. A size 35 file was used lightly to coat the inside of the canal with sealer, the master cone was then lightly coated with sealer and placed into the canal. A finger spreader (size fine, Kerr, Peterborough, UK) was then inserted into the canal to just short of the working length. The spreader was held in place for 10 s then rotated and withdrawn. An accessory cone size fine was lightly coated in sealer and inserted into the space left by the finger spreader. This process was repeated until the canal was completely obturated; the final point was not condensed. The coronal excess was then trimmed with a scalpel flush with the top of the root.

After obturation all teeth were kept in water prior to being radiographed to evaluate the presence of voids. This evaluation was performed according to the criteria stipulated in Table 1 modified from Kersten *et al.* (1987), Gutmann *et al.* (1993) and Dummer *et al.* (1994).

The teeth in each group were dried and the surface of each root, including the apical foramen, coated with two layers of nail varnish (Boots, Nottingham, UK) leaving only the coronal root face and obturating material exposed. Three of the control teeth were sealed coronally and fully coated in nail varnish, the remainder were left open. The specimens were then immersed in black India ink (Windsor and Newton, London, UK) at room temperature (22 + 2°C) for 65 h. Excess ink was washed off the teeth with water and the varnish removed with a scalpel. Each tooth was demineralized in 10% formic acid for 7 days, after which the extent of demineralization was assessed by radiographing the teeth. Following thorough washing with water, dehydration was carried out using 95% alcohol for 15 h and absolute alcohol for 24 h. The teeth were then rendered transparent by storing in methyl salicylate.

The amount of coronal ink penetration was measured using a stereo microscope (Wild MC3 Stereomicroscope; Leitz Ltd, Luton, Beds, UK) and a graticule calibrated in millimetres. Depth of penetration was measured linearly from the coronal surface of the root to the most apical penetration of the ink. The mean leakage was recorded for each group together with the standard deviation. Initial analysis revealed a non-normal distribution and statistical analysis was performed using the Kruskal-Wallis test for nonparametric data to determine whether there were significant differences between the groups. Pairs of groups were compared using the Mann-Whitney *U*-test.

Table 1 Table showing the criteria used for scoring radiographic voids

Rating	
0	Consistently dense, radiopaque fill in middle and coronal thirds, gutta-percha well adapted to canal outline
1	Minimal variation in density throughout, some evidence of small voids (< 0.5 mm) or instrument tracks < 10% of total fill
2	Voids > 0.5 mm but < 1.0 mm
3	Voids > 1.0 mm

Results

The results of the radiographic evaluation can be seen in Fig. 1; statistical analysis showed no significant differences between the groups (Kruskal–Wallis, $P > 0.05$). The mean leakage values together with the standard deviations for the four experimental groups can be seen in Fig. 2. There were significant differences between the groups (Kruskal–Wallis, $P < 0.001$). Mann–Whitney paired group comparisons showed significant differences between: System B and Alphaseal ($P < 0.001$); System B and lateral condensation ($P < 0.001$); Obtura II and Alphaseal ($P < 0.001$); and Obtura II and lateral condensation ($P < 0.001$). No significant differences between the System B and Obtura II ($P > 0.05$) or Alphaseal and lateral condensation ($P > 0.05$) groups were found.

The completely sealed control group showed no leakage, whilst the unsealed group showed complete penetration of the ink.

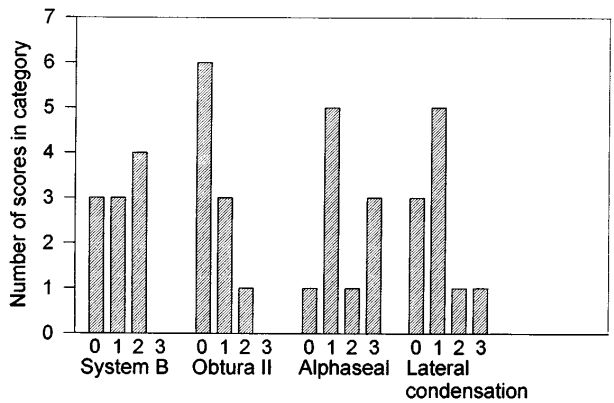

Fig. 1 Graphical representation of the distribution of scores for voids ($n = 10$, 1 SD).

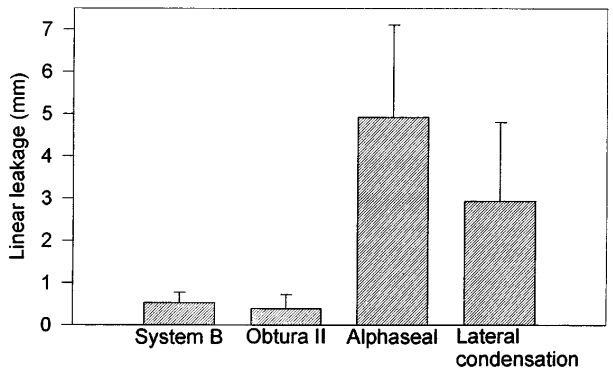

Fig. 2 Graphical representation of the linear leakage in millimetres ($n = 10$, 1 SD).

Discussion

The importance of coronal leakage as a cause of failure in root canal therapy has been emphasized previously (Allison *et al.* 1979, Madison & Wilcox 1988; Saunders & Saunders 1992, 1994). Lower premolar teeth were selected for this study as it was felt that the oval, cross-sectional nature of the canals in the coronal third would test the obturating capabilities and seal of the different backfilling systems to a greater degree than round canals.

A proximal radiographic view was chosen to evaluate the quality of fill as it has been shown to provide a better prediction of the gutta percha adaptation in ovoid canals (Kersten *et al.* 1987). Radiographic evaluation showed that the backfill in the Alphaseal group had voids, especially along the root canal walls. The radiographic appearance of a densely obturated root canal does not indicate that the seal is adequate, it is likely however, that a poorly adapted root filling will leak more and this was borne out in this study.

The technique of using cleared teeth to assess ink penetration has been used in previous studies (Robertson *et al.* 1980, Tagger *et al.* 1983, Saunders & Saunders 1990, Felstead *et al.* 1994) and allows the specimens to be evaluated in three dimensions. The Alphaseal group showed the most coronal leakage, followed by lateral condensation with there being no significant difference between these two groups. Both Alphaseal and lateral condensation performed worse than System B and Obtura II, which were not significantly different. Four teeth in the lateral condensation group showed leakage between individual points despite the last cone not being condensed in order to try to avoid spreader tracts. This finding emphasizes the fact that radiographic findings do not necessarily reflect leakage (Kersten *et al.* 1987). The leakage pattern for the Alphaseal group was different in that overall penetration of ink occurred across a broader front. The ink passed along the voids between the canal wall and root filling being therefore greater in bulk compared to lateral condensation. The voids occurred on the lingual or buccal aspects of the canal which were the points furthest away from the centre of rotation of the condenser. It may be therefore that better results could be produced in round canals. The root canal filling may be improved by routinely using vertical condensation at the end of canal obturation, a technique frequently practised with lateral condensation but not advocated for use with the Alphaseal system. The seal with the Alphaseal system may also improve with the use of both

Multi-Phase I and II. This is not advocated in the manufacturers' instructions but warrants further investigation. Multi-Phase II proved difficult to handle, with it being unpredictable in its placement in the canal. This study only investigated one type of condenser so it is not possible to say whether a different design would have affected the results.

The use of Obtura II involves placing of small aliquots of thermosoftened gutta-percha within the root canal and condensing them individually, this technique produced the least voids radiographically. On the contrary the System B relies on placing cold gutta-percha prior to heating and condensing it *in situ* to improve its adaptability to the canal system. There would appear, in theory, to be a greater chance of voids occurring in the coronal two-thirds of the canal system with the System B. This, however, was not borne out in the present study, which found the incidence of voids and the degree of leakage to be not significantly different to the Obtura II.

The findings of this study have clinical implications in that although the System B appeared to be more difficult to use than the Obtura II there were no significant differences in the end result with respect to voids or leakage. The two groups that involved vertical condensation at the end of obturation produced less leakage and it is recommended that this procedure be adopted as a routine.

Conclusions

- There was no significant difference in radiographic voids or leakage between the System B and Obtura II.
- Alphaseal proved to be unpredictable, producing the most voids and leakage.

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