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The influence of root canal shape on the sealing ability of two root canal sealers

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Abstract

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Aim To evaluate the influence of root canal form on the sealing ability of two root canal sealers.

Methodology Twenty radiographically confirmed straight and 20 curved root canals were prepared with a stepback hand filing technique. Root canal aberrations created during preparation were determined by the use of double exposure radiographic technique. The prepared canals were filled with lateral condensation of gutta-percha and one or other of two root canal sealers (Pulp Canal Sealer and Sealapex). Leakage along the apical 10 mm of roots was measured with a fluid transport model at 1, 3, 6, 9 and 12-month intervals.

Results There were no statistically significant differences between straight and curved root canals ($P > 0.05$) for prevalence of root canal transportation. The prevalence of apical transportation was 80% in the straight and 85% in the curved root canals. A complete seal was more frequently observed in straight canals compared with curved canals. Utilizing the π^* index, analysis showed the filling with Sealapex allowed more leakage than Pulp Canal Sealer at 1 year.

Conclusion Under the conditions of the study, root canal form influenced short-term sealing ability. In the long-term the seal was affected by the sealer rather than root canal form.

Keywords: fluid transport, leakage, root canal morphology, sealers.

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Introduction

During root canal cleaning and shaping procedures canal aberrations (e.g. zip, elbow, perforations) may be created. In most studies, curved root canals had significantly more aberrations compared with straight root canals (Dummer *et al.* 1989, Nagy *et al.* 1997a). The convex wall of the apical portion of a curved root canal may be over-instrumented, removing excess dentine. The concave wall may be untouched (Zuolo *et al.* 1992) creating apical transportation (AT). Leung & Gulabivala (1994) did not find a statistically significant difference in shaping deformities between straight and curved root canals. More recently, Wu *et al.* (2000a) found a statistically significant negative effect of apical transportation (AT) on the seal of root filling. They found that after hand filing, AT and perforations occurred in 87% of the curved root canals and concluded that the occurrence of AT is a factor that negatively influences the apical seal when curved canals are filled by lateral condensation of gutta-percha.

Leakage along root fillings may increase or decrease with time. Dissolution of sealer may result in more leakage (Kontakiotis *et al.* 1997) whereas swelling of gutta-percha may result in diminished leakage (Wu *et al.* 2000b). Sealer coverage of the root canal after lateral condensation of gutta-percha was approximately 50% (Wu *et al.* 2000c) with the result that its physical and chemical properties, such as the thickness of the sealer layer, may also play an important role in

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sealing the root canal (Wu *et al.* 1994). Sealapex (Kerr Manufacturing Co., Romulus, MI, USA) had significantly more leakage after being stored in water for 1 year than other sealers (Wu *et al.* 1995). After storage in water for 2 years there was no significant difference between Sealapex and Pulp Canal Sealer, however, zinc oxide containing sealers had more leakage than Sealapex when applied in a thick layer (Kontakiotis *et al.* 1997). The aim of this study was to determine the influence of the procedural apical transportation on the short-term and long-term sealing ability of two root canal sealers in the case of straight and curved root canals.

Materials and methods

Forty human teeth with a single canal and patent foramen were selected for the investigation. The teeth had been stored in buffered formaldehyde solution (pH 7.25) before they were used. Each tooth was embedded in a $15 \times 15 \times 20$ mm resin block. Two stainless steel markers with different diameters were embedded at the corners of each resin block. After access preparation and extirpation of pulp remnants, a size 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was inserted into each root canal and digital radiographs (RVG, Trophy, France) were taken from both a buccal and proximal view. On the basis of their radiographic images, the teeth were divided into two groups of 20 straight and 20 completely curved root canals according to a fourth degree polynomial approximation computer graphic classification (Nagy *et al.* 1995).

Root canals were cleaned and shaped by one operator using Flexofiles (Dentsply Maillefer) and a stepback technique. The master apical file size was 30 and the canal was flared using a size 45 file. Copious irrigation was provided with 2.6% sodium hypochlorite solution (Hystolith, Lege Artis, Dettenhausen, Germany). To achieve patency a size 10 K-file was inserted into each root canal 1 mm through the apex. A final flush of 5 mL sterile saline solution was used. The groups containing 20 roots were divided in two subgroups ($n = 10$) to test the two different types of sealer. The sealers were the calcium hydroxide containing Sealapex (Kerr Manufacturing Co., Romulus, MI) and the zinc oxide–eugenol (ZOE) containing Pulp Canal Sealer (Kerr Manufacturing Co.). The root canals were filled with one or other of the sealers and lateral condensation of gutta-percha. The apical part of the master gutta-percha cone size 30 was coated in sealer and placed into the canal. Lateral condensation was commenced using a size A finger spreader (Dentsply Maillefer) and auxiliary gutta-percha points of identical sizes (Dentsply Maillefer). Excess gutta-percha was removed with a hot instrument. All of the roots were kept at 20 °C (100% humidity). The cleaning and shaping procedures and root canal fillings were performed by one operator.

Assessment of canal preparation

Two-positional postoperative digital radiographs were taken as before. Transportation created during canal preparation was identified by the superimposition of pre- and postoperative radiographs. Superimposed, standardized 1:10 projections of the original canal path and the filled canal in m-d and b-l views were used to evaluate the difference in shape between the filled and the original canal. Accurate location and superimposition of the radiographs in both views was facilitated by the presence of two markers at the corners of each block. The radiographic assessments included measurements of the prevalence and the determination of apical transportation (AT). The determination of AT was expressed by the maximum asymmetry of preparation using the method described by Nagy *et al.* (1997b). Briefly, the measurements were carried out perpendicular to the axis of the original canal, using the method described by Briseno *et al.* (1993). The original canal width was divided into two halves, thus defining a point of the canal axis, which served as a reference point for the measurement of asymmetry. Asymmetry (expressed as an absolute value) was calculated by the subtraction of the left from the right canal width on either side of the reference point. The canal width changes were measured at 10× magnification to the nearest 0.1 mm using a ruler.

Fluid transport measurements

After complete setting of the root canal sealers (the setting time of Pulp Canal Sealer is 6 h and for the Sealapex is 40 min) the teeth were decoronated to obtain a 10 mm root length. The outer surface of the roots were modified for the fluid transport investigation in the following way. A highspeed water-cooled handpiece with a diamond fissure bur was used to create a more circular outline of the roots. The method to measure fluid transport was as described by Wu *et al.* (1993). The set-up was placed in a water bath (20 °C) and the air bubble was adjusted with a syringe to a zero position within the microcapillary tube. A headspace pressure of 1 atm. from the inlet side was applied to force the water through the voids along the filling, thus displacing the air bubble in the capillary tube. The volume of the fluid transport was measured by the movement of the air bubble, the results were recorded in μL day^{-1}. The measurements were taken immediately after the setting of the sealer and repeated at 1, 3, 9, and 12-month intervals. The seal of the root fillings were categorised according to Wu *et al.* (1993).

1. 0–0.4 μL day^{-1} (score 1)
2. 0.4–20 μL day^{-1} (score 2)
3. more than 20 μL day^{-1} (score 3)

One-way ANOVA and Duncan's multiple range tests were used for a statistical analysis of the AT values. The power of the sample was determined as described by Schuurs *et al.* (1993).

The microleakage results in relation to the two different materials and root canal forms during the 1-year experimental period were analysed with the help of the π^* index (Rudas *et al.* 1994). This method is an alternative to a classical loglinear analysis and is also useful for small samples.

Results

Assessment of canal preparation

The prevalence of apical transportation (AT) was 80% in the straight and 85% in the curved group.

Mean transportation values at the apical level in buccal and proximal views are given in Fig. 1. The mean AT value was 0.095 mm (SD 0.063) in straight canals in the buccal view. This value was 0.074 mm (SD 0.077) in the proximal view. In curved canals this value was 0.112 mm (SD 0.063) in the buccal view. In the proximal view the value was 0.087 mm (SD 0.074) in the curved group. The difference in mean AT values was not statistically significant ($P > 0.05$), the power of the sample was F > 0.80.

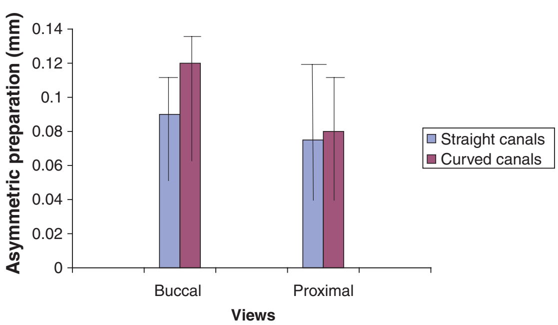

Figure 1 Mean apical transportation values in the straight and curved canals.

Fluid transport measurements

In the straight root canals of the Sealapex group (Fig. 2), results obtained at 1-month were the same as the baseline. At 3 months the seal decreased considerably and similar results were obtained at 12 months. In curved canals of the Sealapex group (Fig. 3) the number of specimens with a score of 1 decreased continuously with time beginning with the first month.

At 12 months in straight and curved canals the seal created by Sealapex showed similar results. In the Pulp Canal Sealer groups straight root canals had minimal leakage at 9 and 12 months (Fig. 4), while in curved root canals leakage appeared at 1 month with additional leakage observed at 12 months (Fig. 5).

Analysis of the results according to canal shape revealed that the seal in straight canals became

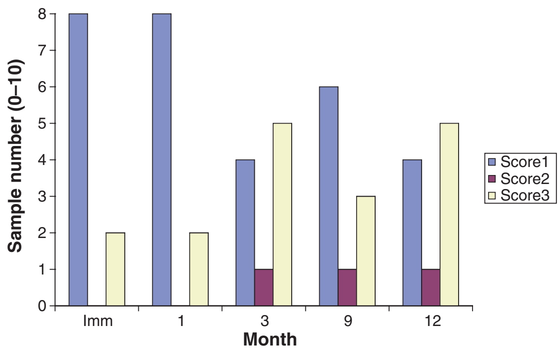

Figure 2 Leakage in straight canals filled with Sealapex.

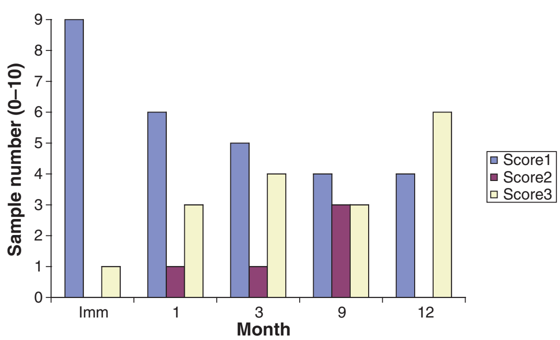

Figure 3 Leakage in curved canals filled with Sealapex.

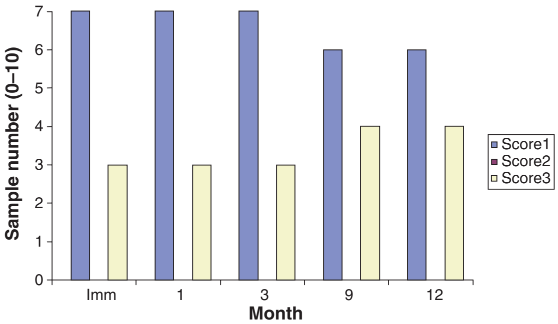

Figure 4 Leakage in straight canals filled with Pulp Canal Sealer.

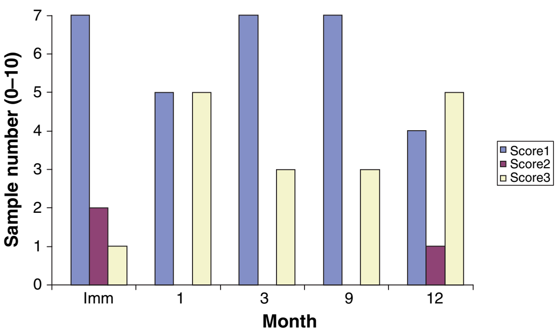

Figure 5 Leakage in curved canals filled with Pulp Canal Sealer.

compromised after the first month, while in curved canals leakage appeared within the first month. Analysis of results according to the type of sealer revealed that at the end of 1 year there was more leakage with Sealapex than with Pulp Canal Sealer. The parameter estimates imply that the root canal form affects the sealing ability at 1-month, while after 1 year the quality of the seal is determined by the choice of the sealer material. The π^* index was 0.04.

Discussion

In the present study the prevalence of AT in curved canals was similar to that reported by Wu *et al.* (2000a), but comparison with that work showed significant differences in the prevalence of AT in straight canals. In the present study 80% of straight canals had AT. This surprising result can be accounted for both by the morphology of human root canals and the sensitivity of the methodology. Roots grouped as 'straight' may have slightly curved canals (Nagy *et al.* 1995). This relatively high prevalence of apical transportation in straight canals has been discussed previously (Nagy *et al.* 1997a). Wu *et al.* (2000a) in their study could identify AT only when 0.2 mm or more. The preparation asymmetry measurement (Nagy *et al.* 1997a,b) is a more sensitive quantitative method for determining AT values. In the present study all the AT mean values were smaller than 0.2 mm both in the straight and curved canals. These AT values were not statistically significant different between straight and curved canals.

The solubility of sealers can negatively influence their long-term seal (Ørstavik 1983). In many longitudinal studies (1–2 years) filling techniques or different sealers were compared (Georgopoulou *et al.* 1995, Wu *et al.* 1995, Kontakiotis *et al.* 1997, Wu *et al.* 2000a,b,c). In the present study Sealapex allowed more leakage than Pulp Canal Sealer. The observed fluctuation in values of score 1 both in straight canals of the Sealapex group and in the curved canals of the Pulp Canal Sealer group could be the result of several factors. A similar fluctuation was observed in score 3 values in the groups of straight and curved canals with Sealapex and in curved canals of the Pulp Canal Sealer groups. These fluctuations may be associated with the different characteristics of the materials, namely, the expansion of gutta-percha when moist and sealer dissolution altering with time.

Wu *et al.* (1995) reported that ZOE containing Tubliseal had significantly less leakage than Sealapex after 1 year. This observation is in agreement with the result of the present study. Others found less leakage with Sealapex than with Pulp Canal Sealer following 1 year (Georgopoulou *et al.* 1995) and 2 years (Kontakiotis *et al.* 1997). The inconsistency among the studies may be explained by the difference in sample storage. In other studies the specimens were stored in water whereas in the present study 100% humidity was used. Storage in water may predispose the dissolution of sealer but this may not be the case in 100% humidity.

Conclusions

1. Under the conditions of the study, root canal form influenced short-term sealing ability.
2. The effect of canal curvature had a decreasing impact on leakage over time.
3. In the long-term the seal was affected by the sealer rather than root canal form.

Acknowledgements

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