A temporary filling material may cause cusp deflection, infractions and fractures in endodontically treated teeth

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Abstract

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Aim To test the hypothesis that Coltosol F might cause infractions and cusp fracture in root-filled teeth because of material expansion.

Methodology Thirty-two extracted human molar teeth were root filled and prepared with mesial-occlusal-distal (MOD) cavities with or without undercuts. The specimens were filled proximally with glass–ionomer cement and then occlusally with either Coltosol F or zinc oxide eugenol (ZOE). The tooth specimens were kept in water at 37 °C for a period of 20 days, and every second day the intercusp distance (ICD) of each specimen was measured in a travelling microscope, and the number of infraction lines as well as fractures were noted.

Results The number of infraction lines increased in teeth filled with Coltosol F. Between day 8 and 16, seven of 16 teeth filled with Coltosol F showed fracture and exhibited a mean increase in ICD of 316 ± 156 μm. Teeth filled with ZOE did not show an increase in number of infraction lines or in ICD, and none showed fracture.

Conclusions The hygroscopic expansion of Coltosol F in a cavity may lead to cusp deflection, infraction development and fracture. Masticatory forces will *in vivo* aggravate this unfavourable condition. The material is not recommended for temporary filling in root-filled teeth except for a few days.

Keywords: expansion, root canal treatment, temporary filling, temporization, tooth fracture.

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Introduction

Coltosol F® (Coltène/Whaledent Inc., Altstätten, Switzerland) may be chosen as temporary filling material because of its easy handling qualities and ease of removal. However, the material might possess an undesirably high tendency to expand because of water uptake. Coltosol F consists of 40% zinc-calcium sulphate-hemihydrate and has a hygroscopic expansion of 17–20 vol.% according to the manufacturer. Apparently, the material has not been properly tested (Naoum & Chandler 2002). In a previous *in vivo* investigation (Laustsen *et al.* 2004), tooth fractures occurred among root-filled teeth with occlusal fillings of Coltosol F. This observation initiated the present investigation with the aim of testing the hypothesis that the hygroscopic expansion of Coltosol F in a cavity might cause such a pressure against the surrounding cavity walls that the opposing cusp distance would increase, and subsequently lead to infraction development and cusp fracture.

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Materials and methods

Thirty-two extracted human molar teeth were maintained in 0.5% aqueous chloramine T until use. The

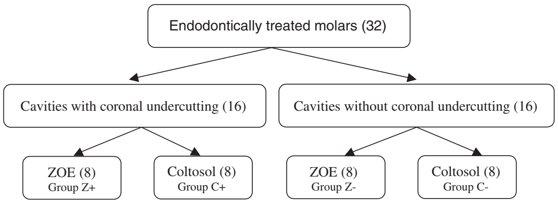

Figure 1 Design of experiment, with number of specimens in parenthesis.

roots were embedded in Epofix kit (Struers A/S, Copenhagen, Denmark), and root canals were sequentially enlarged with nickel-titanium rotary instruments. Two protocols were used, one with RaCeTM instruments (FKG Dentaire, La Chaux-de-Fonds, Switzerland) and the other with System GT® instruments (Dentsply Maillefer, Ballaiques, Switzerland) modified with an apical enlargement using Profile® (Dentsply Maillefer) as described by Kvist *et al.* (2004). All canals were instrumented to 1 mm from the apical foramen, with an apical stop corresponding to size 40. The canals were filled with gutta-percha using cold lateral condensation of gutta-percha with Apexit® (Ivoclar Vivadent, Schaan, Lichtenstein) sealer. The teeth were divided into two groups, A and B (Fig. 1) with 10 maxillary and six mandibulary molars in each. In each group half of the specimens were instrumented with the RaCe files and half with GT files.

Standard mesial-occlusal-distal (MOD) preparations were made in each group (cavity depth 6 mm, proximally prepared 1 mm above the enamel-cemento junction and with a bucco-lingual width of 5 mm). The preparations were completed with a diamond bur leaving the inner line angles rounded; in group A with coronal undercutting and in group B without (Fig. 1). Undercut cavities were confirmed by inspecting specimens with a probe after preparation. The thickness (mean ± SD) of the buccal and palatal/lingual walls was 2.9 ± 0.44 mm.

The gutta-percha was cut back into the opening of the canals and a calcium hydroxide-containing cement (Dycal, Dentsply International, York, PA, USA) was placed. The teeth were filled (as outlined in Fig. 1) either with Coltosol F or zincoxide eugenol (ZOE) (Skanderborg Pharmacy, Skanderborg, Denmark). Small marks were made on opposing cusps with a flame-shaped diamond (Komet, ISO 806, Lemgo, Germany) (Fig. 2). This enabled measurement of the intercusp distance (ICD) by a travelling microscope (Gaertner, Scientific corporation serial number 111P, Chicago, IL, USA), which was equipped with a micrometer. Fixed locations at the circles around the two marks were used as measuring points as indicated in Fig. 2. The tooth specimens were stored in water at 37 °C, and the water was changed every fourth day.

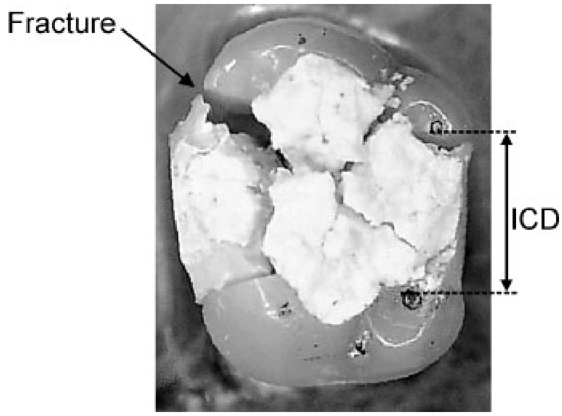

Figure 2 Tooth prepared without undercut and filled with Coltosol F. Occlusal view after several days in water. Note measuring marks for intercusp distance and a cusp fracture.

The ICD was measured within the first hour after filling and then every second day for a period of 20 days. The same protocol was used to stain the teeth with 8% aqueous erythrosine and to count the number of infraction lines in a microscope at low magnification. The measurements ended when a tooth fractured.

Statistical analysis

The data were evaluated by Fishers exact probability test and by Student's *t*-test with a level of significance of 5%.

Results

The accuracy of the measurements made with the travelling microscope can be judged by the variation with time of the ICD for each tooth in the control group. This judgement showed a mean coefficient of variation of 0.2%. The control group showed that the glass–ionomer cement (GIC) placed proximally did not contribute to expansion caused by water storage.

The variation of ICD over time in the Coltosol F groups is displayed in Figs 3 and 4. For the undercut specimens group (group C+, Fig. 3), fractures occurred in five cases after 8 days or more in water. For the specimens without undercuts (group C−, Fig. 4), fractures were observed in two cases, both after 8 days in water. The difference between the two groups was not statistically significant ($P = 0.16$). The mean increase

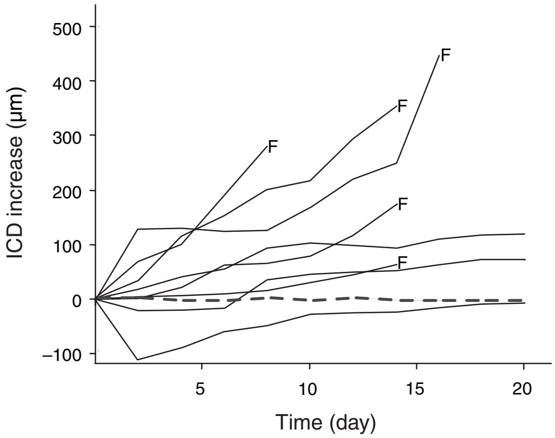

Figure 3 Increase in intercusp distance vs. time in water for each of eight tooth specimens filled with Coltosol F and prepared with undercuts (group C+). F denotes fracture. The broken line indicates the results with zinc oxide eugenol specimens.

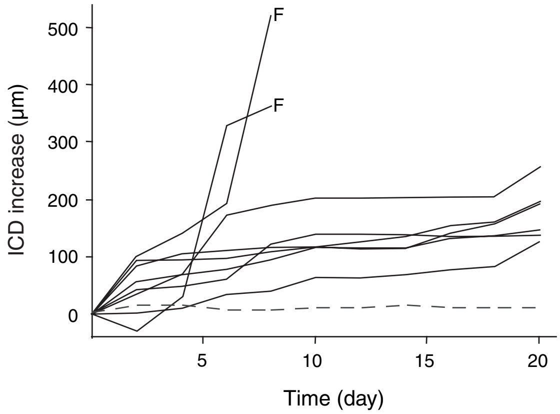

Figure 4 Increase in intercusp distance vs. time in water for each of eight tooth specimens filled with Coltosol F, and prepared without undercuts (group C–). F denotes fracture. The broken line indicates the results with zinc oxide eugenol specimens.

in ICD at day 8 did not differ significantly between the two groups ($t = 1.41$; $P = 0.09$).

The variations of the ICD over time in the teeth filled with ZOE were small. The largest difference between two means in each of the two groups (Z+ and Z–, Fig. 1) was 12 µm. There was no statistically significant difference ($t = 1.8$; $P = 0.5$) in mean ICD at day 0 and day 20 in any of the two groups. No infractions or fractures developed or were observed.

The fracture frequency of teeth filled with Coltosol F (7/16) and ZOE (0/16) differed significantly ($P = 0.0034$). Three fractures were noted among teeth prepared with GT/Profile instruments and four in the teeth prepared with RaCe instruments.

In the Coltosol F groups, the mean width of the thinner of the two cavity walls was 3.0 ± 0.41 mm and that of the thicker 3.5 ± 0.38 mm. The mean increase of ICD for the seven fractured specimens was at break, 316 ± 156 µm. This value was significantly different from the mean increase of those without break after 20 days in water (138 ± 75 µm) ($t = 3.00$; $P = 0.005$).

In teeth filled with Coltosol F the number of infractions increased through the entire test period. The results from the combined Coltosol F groups are illustrated in Fig. 5.

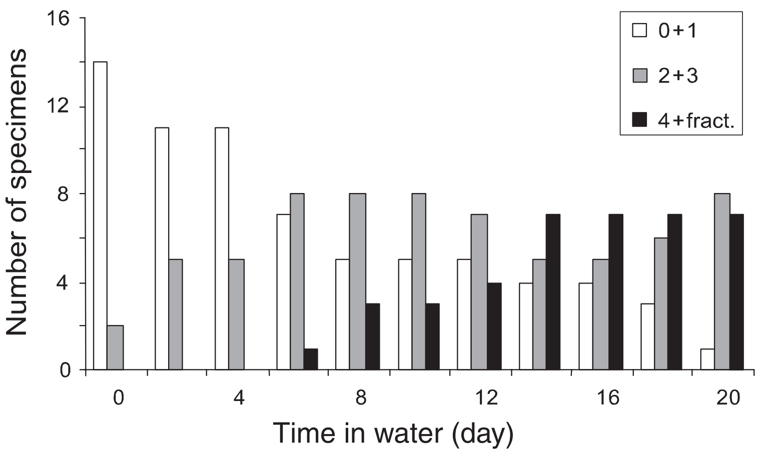

Figure 5 The development of infractions in teeth filled with Coltosol F. White columns, zero or one infraction; grey columns, two or three infractions; black columns, four infractions or facture.

Discussion

The teeth in the present experiment were root filled to resemble the clinical situation in a previous study (Laustsen *et al.* 2004), and MOD cavities were prepared, because isolated cusps will be at greater risk for fracture than cusps surrounding simple occlusal cavities. The proximal parts of the cavities were filled with glass–ionomer restorative (Fuji II LG, GC Europe N.V., Leuven, Belgium). The cavities were restored with proximal glass–ionomer restorative before filling with provisional cement: (i) in order to secure that a hygroscopic expansion of the provisional cement might cause expansion directed in the bucco-lingual direction, and (ii) to reflect an optimal clinical working field avoiding leakage from proximal surfaces between visits. GIC possesses some bonding capability to enamel or dentine, which might ensure that an expansion would be directed in the bucco-lingual direction. ZOE was chosen as control material because of its modest dimensional changes during setting and water absorption (Ørstavik *et al.* 2001).

For tooth specimens filled with Coltosol F, the distance between opposing cusps increased with time in water from 0 to 20 days (Figs 3 and 4). This was in contrast to the results obtained with the specimens containing ZOE, which showed insignificant changes.

Coltosol F-filled specimens with undercut cavities fractured at greater rates, which were not statistically significant from those without undercut (5/8 and 2/8 respectively). Thus, the importance of the undercut cavity is still an open question. The fractures were evenly distributed between the two types of root canal preparation, indicating its small impact on the results.

Seven of 16 teeth filled with Coltosol F were fractured. The mean increase in ICD at break was 316 μm, as compared with 138 μm for the remaining Coltosol F specimens that did not fracture. This finding could not be explained by differences in the thickness of the cavity walls, but might be explained by biological diversity, including differences in age of the teeth and differences in loads during their previous function in the mouth. Infractions are a recognized problem but mainly in heavily restored teeth (Brynjulfsen *et al.* 2002). Infractions may develop because of masticatory load, but as seen in Fig. 5, filling with Coltosol F may have the same effect.

Several dental materials are known to expand, but the extent of expansion varies. Amalgam may expand around 3 vol.% in 3 years (Jensen & Jørgensen 1985), and for amalgam fillings with relatively low creep, this might lead to tooth fractures (Hansen & Asmussen 1993). Resin-modified GIC expand more than conventional GIC, and with volumetric changes below 6 vol.% (Cattani-Lorente *et al.* 1999).

van Dijken (2002) found cusp fractures with a frequency of 26% within 3 years in a clinical study with a special glass–ionomer-based composite. One of the possible explanations that were given was water uptake leading to expansion. Ørstavik *et al.* (2001) expressed fear of root fracture because of expansion of sealers, and Nelson & Mahler (1990) have expressed fear of root fracture because of expansion of zinc-containing amalgam contaminated with water and when used for root end filling following root resection.

The demonstrated expansion of Coltosol F might cause stress in the material as well as the surrounding walls. The stress might partly dissipate because of expansion of material out of the cavity, by a deformation of the walls and by creep or other stress-releasing mechanism. When the stress-induced deformation reaches a certain limit, cracks will develop both in the inner part of the dentine walls as well as between enamel and dentine because of their different mechanical properties. In the present study, the measured increase in ICD at break was 316 ± 156 μm. This increase might depend on several parameters, including cavity form and thickness of the walls, which varies in the present study. The relatively large standard deviation may be explained by these variations, and by the phenomenon that the Coltosol F material expands out of the cavities in steps rather than in a smooth linear fashion. In addition, rupture of the bond between the glass–ionomer and tooth might appear at different time intervals. This may explain the irregular slopes of the lines in Figs 3 and 4.

Conclusion

The hygroscopic expansion of Coltosol F in a cavity may lead to cusp deflection, infraction development and fracture. Masticatory forces will *in vivo* aggravate this unfavourable condition. The material is not recommended for temporary filling in root-filled teeth except for a few days.

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