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Comparison of fracture resistance in root canals of immature sheep teeth after filling with calcium hydroxide or MTA

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Andreasen JO, Munksgaard EC, Bakland LK. Comparison of fracture resistance in root canals of immature sheep teeth after filling with calcium hydroxide or MTA. © Blackwell Munksgaard, 2006.

Abstract – Thirty immature sheep incisor teeth were tested for their fracture resistance after various treatment modalities using calcium hydroxide (CH) or a mineral trioxide aggregate material (MTA®) as a root filling. The incisors, having approximately 80% of their root growth completed, were removed from jaws of slaughtered sheep and divided into four experimental groups. The pulps were extirpated from all the teeth through the open apexes. (a) Saline group: the teeth were preserved in saline for 100 days at 6°C. (b) CH group: the root canals were filled with CH and sealed apically with IRM® and stored as above. (c) MTA® group: the canals were filled with MTA® and stored as above. (d) CH + MTA® group: the canals were filled with CH and sealed with IRM®. After 30 days, the CH was replaced with MTA® and stored as above. At the end of the 100-day storage period, all teeth were embedded in plaster of Paris and tested for fracture strength at the cervical area in an Instron® testing machine. The results showed a decrease in fracture resistance (a) of the incisors with CH in the root canals after 100 days of storage, compared to (b) teeth stored in intracanal saline and (c) teeth with 30 days of CH and then filled with MTA®, and (d) those filled with MTA in the canals. In conclusion, when CH was kept in the canals of immature sheep teeth for only 30 days followed by root filling with MTA® there was no significant decrease in strength of the root within an observation period of 100 days. This finding may be of importance in the decision of treatment plans for teeth with pulp necrosis and immature root formation.

Key words: fracture resistance; immature teeth; calcium hydroxide, MTA®

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It has been pointed out by Cvek (1) that endodontically treated immature teeth have a relative high (>60%) incidence of cervical root fracture either spontaneously or due to minor impacts. The hypothesis was that long-term exposure to calcium hydroxide (CH) may weaken the dentin and thus making the roots more susceptible to fracture. In a previous paper (2), it was demonstrated that CH in long-term contact with root dentin does reduce its resistance to fracture. Exposure-time of 30 days or less had little impact, while 60 days or more had significant impact on the fracture resistance. It was therefore concluded that short-term use of CH (30 days or less) for disinfecting necrotic root canals was acceptable.

Alternatives to CH have been proposed, the most promising being a recently developed material, mineral trioxide aggregate (MTA®) (3). MTA (ProRoot MTA, Dentsply, USA) is a material consisting of tricalcium oxide and other mineral oxides. It also, like CH, shows alkaline reaction in aqueous slurries (pH≈11). MTA was initially developed for sealing root canal perforations (4, 7) and was found suitable for other endodontic applications, such as for apical retrofilling (5, 7) and pulp capping (6, 7).

MTA's suitability as material for use in immature teeth, in which root development was interrupted due to pulp necrosis was investigated (3). The results demonstrated that MTA® promotes apical closure equal to that seen with CH.

Since MTA has a pH in aqueous slurry quite similar to that of CH and since this alkaline reaction has explained CH's effect on dentine's fracture resistance (2), it was decided to compare the two material's effectin terms of effects on the root dentin's fracture resistance. The hypothesis was that there would be no difference.

Material and methods

Mandibular incisors with immature root formation were harvested form young, slaughtered sheep, approximately 4 months old. Immediately upon removing the teeth from the sheep jaws, the pulps were extirpated through the open apexes using Hedströms files (to engage the pulp tissues). The teeth were then placed in saline and stored in a freezer (<0°C) until used in the experiments. A total 30 teeth were used and divided into the following groups: (a) Saline group, (b) CH group, (c) MTA group, (d) CH + MTA group.

Treatment procedures

The teeth were removed from the freezer, allowed to thaw, and divided using the four treatment groups. The teeth in the saline group were flushed with saline from the apical opening, then filled with saline and then IRM® (Dentsply®, De Trey, Germany) was placed to a depth of approximately 3 mm at the apical end to seal the canal. The teeth in the CH group were similarly rinsed internally from the apex using saline, dried with paper points filled with CH (Calacept®, Sweden) and then sealed apically with IRM.

The teeth in the MTA group were rinsed with saline but not dried with paper points since the presence of moisture in the canals promote curing of the material. The MTA was condensed from the apex into the canals and coronal pulp spaces using pluggers and leaving it *flush with the apex* (Fig. 1). It was not necessary to seal these teeth with IRM. The last group of teeth were first filled with CH, which was kept in place for 30 days, then replaced with MTA as described above. All the groups of teeth were stored for 100 days in saline at 6°C until prepared and tested for fracture resistance.

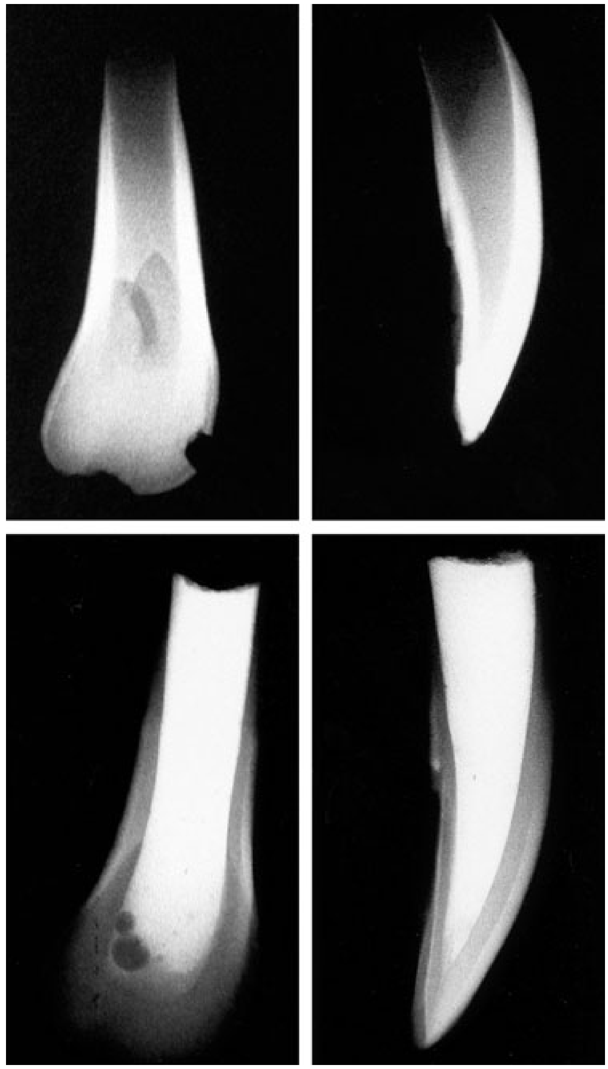

Fig. 1. Frontal and lateral aspects of extracted immature sheep incisors unfilled and filled with MTA

Fracture testing. Each tooth was embedded in a block of plaster of Paris, 27 × 13 × 40 mm, in such a way that the long axis of the tooth was aligned with the central axis of the plaster block, which covered the entire root and part of the crown. The embedded specimens were kept in water for 24 h to ensure setting of the plaster, after which the top surface of the plaster was removed with a scalpel until the enamel–cementum border was exposed. Each specimen was mounted in an Instron® testing machine (Instron, High Wycombe, UK) and a spade used for transmitting pressure was placed against the facial crown surface parallel to the incisal edge and with the end 2.5 mm from the incisal edge. The spade was pressed against the specimen at a speed of 1 mm min^{-1} until fracture occurred. The fracture strength was calculated in MPa (8). The

Table 1. Mean fracture strength after 100 days treatment period of teeth with the canals filled with either saline, CH, MTA or with CH for 30 days, then with MTA® for the rest of the period

Treatment group	*n*	Fracture strength, MPa (SD)
Saline	9	310.3 (±63.04)
CH	6	225.5 (±78.84)
MTA	7	330.8 (±99.13)
CH + MTA	8	326.7 (±84.03)

Table 2. Intergroup comparison of difference in fracture strength

	Saline	CH	MTA
CH	$P = 0.03$		
MTA	$P = 0.54$	$P = 0.07$	
CH + MTA	$P = 0.65$		$P = 0.86$

mean and standard deviation (SD) for each group was calculated and the results from all the groups were compared and tested with a *t*-test at a 5% level of significance.

Results

Table 1 shows the mean fracture strengths and SD for each of the four groups.

The results from the statistical comparisons among the groups are shown in Table 2. As seen, only when the results from the saline groups are compared with the experiment with 100 days exclusively, is a significant difference observed ($P = 0.03$).

Discussion

The results in the present study showed us a significant reduction in fracture resistance (22%) by long-term use of CH (i.e. 3 months), a finding, which was also found in a previous experiment (2).

The conclusion in the previous study was to analyse whether alternative methods could be found to replace the long-term use of CH.

The main reason for long-term use of CH has been the initiations of an apical hard tissue barrier, which has been found to take place after 9–18 months (9, 10). Prolonged exposure of dentin to CH has apparently a weakening effect of dentin due to the proteolytic capacity of CH (11). As MTA has been found to be able to ensure a tight closure of an apical foramen and also to promote cementum coverage directly upon the MTA-surface a double seal of the root canal can be achieved (3, 5, 6). This treatment modality is thus a promising new treatment possibility.

The present study should be seen as an in-vitro test to examine whether the combination of short-term use of CH followed by root filling with MTA would prevent the above-mentioned weakening of denting.

In conclusion one month's placement of CH in the root canal with the purpose of disinfecting the root canal and dentinal tubules, dissolving pulp remnants and also drying up the apical zone in preparation for filling the root canal with MTA, appears from a mechanical point of view (fracture resistance) to be a good alternative to long-term use of CH prior to filling with gutta percha and a sealer.

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