

# Comparative Study of Calcium Hydroxide Extrusion with Different Techniques of Intra-Canal Placement

## SUMMARY

**Introduction:** To investigate  $\text{Ca}(\text{OH})_2$  extrusion from the apical foramen in relation to the placement mode.

**Methods:** 200 teeth, prepared with ProTaper files with and without apical patency, were divided in Groups A and B respectively, and filled with  $\text{Ca}(\text{OH})_2$  at 1 and 3 mm short of working length, using K-files manually and with mechanical spiral techniques (Pastinject/Lentulo) at 500 and 700rpm. Extrusion was graded as present/absent. Experimental categories were compared using Fisher's exact test.

**Results:** Extrusion was observed only in teeth with patency. There was no extrusion with K-files in all cases and with Pastinject and Lentulo inserted at 3 mm short of working length. Speed elevation did not significantly increase the extrusion cases.

**Conclusions:** K-files tend to be safer than mechanical techniques. Pastinject and Lentulo at 3 mm short of working length prevented  $\text{Ca}(\text{OH})_2$  extrusion. Raising speed from 500 to 700 rpm did not significantly increase the extrusion risk.

**Keywords:** Calcium Hydroxide; K-files; Lentulo; Pastinject; Patency; Rotation Speed

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ORIGINAL PAPER (OP)

Balk J Stom, 2011; 15:5-10

## Introduction

Calcium hydroxide  $\text{Ca}(\text{OH})_2$  is widely used as an intra-canal medicament. A homogenous and sufficient in length, obturation of the root canal space with  $\text{Ca}(\text{OH})_2$  is essential in order to benefit from the paste's antimicrobial effect.

Several techniques and specialized instruments for intra-canal placement of  $\text{Ca}(\text{OH})_2$  have been advocated. These can be divided into 3 main categories: (a) **spiral techniques**, performed with hand endodontic instruments, most commonly with K-files rotated counterclockwise, or by mechanically rotating instruments used in various speeds ranging from as low as 150rpm for Nickel-Titanium instruments, 500rpm to 1000 rpm for the Lentulo paste carrier and the Pastinject (MicroMega, Besancon, France), moderate speed (5,000rpm) for the Gutta-Condensor (Maillefer, Ballaigues, Switzerland) to even higher speed (10,000 rpm) for the McSpadden compactor (Ransom and Randolph, Toledo, Ohio); (b) **ultrasonic techniques** using specifically designed instruments mounted on an ultrasonic generator, such as

K-type ultrasonic files and the Meca-Shaper (Maillefer, Ballaigues, Switzerland); and (c) **injection techniques**, such as the Messing Root Canal Gun (Dentsply Maillefer, Ballaigues, Switzerland), the Calasept injection system (Scania Dental AB, Sweden) and the Ultracal syringe system (Ultradent, South Jordan, UT, USA). These last techniques use a syringe and a needle to insert the  $\text{Ca}(\text{OH})_2$  into the prepared root canals. Although commonly the above techniques are used separately, a combination has also been proposed<sup>34</sup>. Following placement of the paste, condensation can be achieved with files, absorbent paper points and manual pluggers.

The effectiveness of current techniques for  $\text{Ca}(\text{OH})_2$  filling of the root canal space varies. Deveaux et al<sup>7</sup> showed that Pastinject and Lentulo provided a better filling in single-rooted teeth compared to Gutta-Condensor, Meca-Shaper and K-type ultrasonic file. Estrela et al<sup>8</sup> concluded that K-files rotated counterclockwise, combined with the use of absorbent paper points and pluggers, achieve better quality of filling with less empty spaces in all thirds of the root canal compared to Mc Spadden compactors, Lentulo spirals

and syringes<sup>8</sup>. When the Pastinject and the Lentulo were directly compared, Pastinject proved to be more effective for placement of  $\text{Ca}(\text{OH})_2$ <sup>7,22</sup>. Similarly, when comparing Lentulo to an injection technique, the Lentulo provided a denser and up to the desired length filling of the root canal<sup>30</sup>. However, it has been suggested that if straight or slightly curved root canals are prepared up to at least size 50, high quality  $\text{Ca}(\text{OH})_2$  fillings can be achieved with a syringe<sup>32</sup>. There is discrepancy in the literature regarding the effectiveness of different techniques. However, there is a consensus that better filling of the root canal space with  $\text{Ca}(\text{OH})_2$  is achieved in root canals that have been adequately instrumented, when compared to those that have been only minimally prepared as is often a case during an emergency appointment<sup>31,32,34</sup>.

During root canal treatment,  $\text{Ca}(\text{OH})_2$  dressing material might unintentionally escape through the root apex into the periapical tissues<sup>4,6,35,21</sup>. Although the effectiveness of various techniques in filling the root canal space has been widely studied<sup>7,8,30-32</sup>, there are no reports in the literature on the effectiveness of those techniques in preventing extrusion into the periapical tissues. Only in a pilot study on plastic blocks<sup>34</sup>, extrusion was noted in cases of patent blocks with the carrier placed at the working length and therefore, in the main study, this was prevented and thus not studied by placing tape where the canal exited the plastic block. The **aim** of this study was to investigate the frequency of extrusion of  $\text{Ca}(\text{OH})_2$  from the apical foramen in relation to the technique of intra-canal placement, the distance from the apical foramen and rotation speed.

## Materials and Methods

200 freshly extracted, fully formed human permanent single-rooted teeth obtained from a pool of teeth were studied. Calculus and conjunctive deposits were removed and teeth were kept in 10% formalin until use. 2 radiographs were taken, 1 from the buccal and 1 from the proximal side of the tooth to verify the existence of a single non-calcified root canal with a curvature of 0-10° according to Schneider<sup>28</sup>. Once the access cavity was prepared, the working length was established radiographically at a distance of 1 mm from the radiographic terminus. The teeth were divided in 2 groups:

**Group A:** The root canals were instrumented with the ProTaper rotary files (Dentsply, Tulsa Dental, Tulsa, OK, USA) according to the manufacturer's instructions, starting with file S1 up to file F3. Between each file, the root canal was irrigated with 2.5% NaOCl using a 27-gauge needle (Ultradent Products INC, South Jordan, UT, USA) placed passively in the canal at 2-3mm short of the working length, and a #10 K-file was placed into the root canal and advanced until the tip of the file passed

1mm from the apical foramen to maintain the patency of the apical constriction.

**Group B:** The instrumentation procedure was identical to that of group A but patency file was not used.

After instrumentation, the root canals were dried with paper points and the teeth were adjusted to holes created through the rubber stoppers of vials and were secured in place using sticky wax. The vials were hand-held. The operator was shielded from seeing the root apex during the filling procedure by a rubber dam that covered the vial.

Pure  $\text{Ca}(\text{OH})_2$  powder (Merck K GaA, Darmstadt, Germany) was moistened with saline and mixed to a relatively thick paste (corresponding to a toothpaste consistency). Then, the specimens of each group were randomly divided into 10 experimental groups comprising 10 teeth each. The groups are presented in table 1.

The entire length of a size # 30 Lentulo spiral (Maillefer, Ballaigues, Switzerland) and a size #30 Pastinject (MicroMega, Besancon, France) file were coated with the paste, introduced in the canal at 1 and 3 mm short of the working length and then rotated at 500 and 700 rpm using a handpiece mounted on a speed and torque control machine (X-Smart, Dentsply, Tulsa Dental, Tulsa, OK, USA). A size #30 K-file (Maillefer, Ballaigues, Switzerland) was coated with  $\text{Ca}(\text{OH})_2$  and introduced into the canal at 1 and 3 mm short of the working length with a counterclockwise rotation resulting in 20 subgroups (Tab. 1). For all 3 techniques of placement, the paste was condensed with a size #10 plugger (Maillefer, Ballaigues, Switzerland), then dried and compacted with the blunt end of a paper point and the procedure was repeated for a total of 3 times for each tooth.

When the intra-canal placement of  $\text{Ca}(\text{OH})_2$  was completed, the tooth-rubber stopper unit was removed from the mouth of the vial and the root ends were viewed under a microscope (OPMI, Carl Zeiss Surgical Inc, Dublin, CA, USA) at x 4.5 magnification. The extrusion of  $\text{Ca}(\text{OH})_2$  was recorded as either present or absent by 2 examiners masked on the group and technique examined. Any amount of  $\text{Ca}(\text{OH})_2$  that past the apical foramen was considered extrusion (Fig. 1a and 1b.). Only if the 2 examiners agreed upon their answer, the answer considered valid. In case of disagreement, a third examiner was consulted. Cases in which there was no consensus were excluded from the study.

Fisher's exact test was used to compare the experimental categories, with the level of significance set at  $p < 0.05$ , to determine statistical significance. All p values were 2-sided. Analysis was performed using SAS software, version 9 (SAS Institute Inc., Cary, NC).

Table 1. 20 experimental sub-groups and the extrusion of  $\text{Ca}(\text{OH})_2$  in relation to the method of intra-canal placement, distance from the apical foramen and rotation speed (rpm).

Group	Technique	Length	Rotation speed (rpm)	Extrusion		
				Yes (N)	No (N)	
A (N=100) With patency	LENTULO (N=40)	-1mm	500	0	10	
		-1mm	700	1	9	
		-3mm	500	0	10	
		-3mm	700	0	10	
	PASTINJECT (N=40)	-1mm	500	3	7	
		-1mm	700	4	6	
		-3mm	500	0	10	
		-3mm	700	0	10	
	K-FILE (N=20)	-1mm	-	0	10	
		-3mm	-	0	10	
	B (N=100) Without patency	LENTULO (N=40)	-1mm	500	0	10
			-1mm	700	0	10
-3mm			500	0	10	
-3mm			700	0	10	
PASTINJECT (N=40)		-1mm	500	0	10	
		-1mm	700	0	10	
		-3mm	500	0	10	
		-3mm	700	0	10	
K-FILE (N=20)		-1mm	-	0	10	
		-3mm	-	0	10	



Figure 1.



Figure 1.

## Results

The number of teeth with extruded  $\text{Ca}(\text{OH})_2$  in each group is shown in table 1. Patency of the apical foramen significantly increased  $\text{Ca}(\text{OH})_2$  extrusion. In group A, K-files used for intra-canal placement of  $\text{Ca}(\text{OH})_2$  prevented extrusion; there were 8 cases of extrusion when mechanical spiral techniques were used; however, there was no statistically significant difference. Insertion of the paste carriers at 3 mm short of the working length constricted the paste inside the root canal more efficiently compared to insertion at 1mm short of the working length, but the difference between them was not statistically significant. At 500 rpm and at 1 mm short of the working length, Pastinject caused extrusion of  $\text{Ca}(\text{OH})_2$  in 3 out of 10 teeth, but the difference was not statistically significant when compared to the Lentulo technique, where no extrusion was detected. Elevating the speed from 500 to 700 rpm did not lead to significantly more cases of extrusion for either Lentulo or Pastinject, although there was a tendency (4 out of 10 cases) for extrusion when using Pastinject at 700 rpm and at 1 mm short of the working length.

## Discussion

Although it is suggested that the deliberate extrusion of  $\text{Ca}(\text{OH})_2$  into the periradicular tissues may have a direct effect on inflamed tissue and epithelial cystic linings and potentially favour periapical healing and encourage osseous repair<sup>35</sup>, it is not widely recommended. Extensive extrusion of  $\text{Ca}(\text{OH})_2$  into the periapical tissues did not appear to compromise ultimate periapical healing<sup>4,6,21</sup>; however, in the majority of cases, it seemed to delay it. Moreover, there are reports of immediate flare up induced by extrusion<sup>6</sup>. Cases with complete healing of the pre-existing periapical lesion even after 3<sup>21</sup> or 4 years<sup>16</sup> with incomplete resorption of the extruded paste containing  $\text{BaSO}_4$  (used to enhance its radiopacity) have also been reported.

The use of  $\text{Ca}(\text{OH})_2$  as an intracanal medicament has been linked with a number of severe side effects. There have been case reports with necrosis of the gingiva and mucosa due to its alkalinity<sup>3</sup>, severe tissue necrosis after intra-arterial injection<sup>29</sup>, orbital pain and headache<sup>36</sup>, severe facial ischemia<sup>18</sup>, mental or inferior alveolar nerve paraesthesia after penetration of the material into the mandibular canal<sup>1,24,27</sup>, formation of antroliths following its extrusion into the antrum<sup>10,12</sup> and foreign body granuloma in the nearby gingival tissues<sup>15</sup>. In mice, inflammatory responses were reported following inoculation of various  $\text{Ca}(\text{OH})_2$  pastes into subcutaneous tissue. The severity of the response varied by the paste type used<sup>5,20</sup>.

In our study, extrusion of  $\text{Ca}(\text{OH})_2$  was recorded as either present or absent. Similarly, previous studies on the extrusion of gutta-percha used the presence and absence of extrusion as a criterion to evaluate the safety of filling techniques in obturating the root canals<sup>25</sup>. The positive/negative criterion is not sensitive enough to distinguish among techniques. However, the consistency of the extruded calcium hydroxide and its contact with the root surface does not allow measurements as in the cases of debris or irrigant extrusion studied extensively in the literature<sup>14,17</sup>. The techniques investigated are among the most widely recommended for intra-canal calcium hydroxide placement in clinical practice and they have been thoroughly investigated for their efficacy<sup>7,8,22,30-32,34</sup>. Thus, it was thought unnecessary to study their filling efficacy. Therefore, this study presents only results of the extrusion of the material, regardless quality of the filling of the root canal in each case, as extrusion in clinical practice is not related to the quality of the filling.

In the present study, extrusion of  $\text{Ca}(\text{OH})_2$  was only recorded in teeth where patency was preserved. Establishing patency of the apical foramen during root canal instrumentation to effectively prevent blockages and loss of working length has been proposed<sup>2,9,11</sup>. Patency facilitates removal of debris from the entire root canal space, especially in teeth with necrotic pulp tissue and bacteria load<sup>13</sup> and improves tactile sense during apical shaping and thus reduces the chances of canal transportation and ledge formation<sup>2</sup>. However, the concept of apical patency is considered controversial due to the differences in the amount of the extruded material found in cases with and without patency filing<sup>2,19,33</sup>. In this study, a #10 K-file was used as patency file as it was found that more material was extruded apically when diameter of the apical patency increased<sup>33</sup>.

A wide range of rotation speeds have been used during the spiral filling techniques, ranging from 150 up to 10,000 rpm<sup>7,8,22,23,30-32,34</sup>. In the present study, elevating rotation speed from 500 to 700 rpm resulted in more cases of  $\text{Ca}(\text{OH})_2$  extrusion in teeth with patent apical constriction, but the difference did not reach statistical significance.

In previous studies on the effectiveness of intra-canal placement techniques of  $\text{Ca}(\text{OH})_2$ <sup>7,8,30-32,34</sup>, the paste carrier was introduced in the root canal at 0 to 3 mm short of the working length. The most effective delivery of  $\text{Ca}(\text{OH})_2$  was achieved when the paste carriers were introduced to working length<sup>31</sup>. In the other cases, some distance of  $\text{Ca}(\text{OH})_2$  from the working length was observed<sup>22</sup>. In the present study, the extrusion of  $\text{Ca}(\text{OH})_2$  from the apical foramen was recorded when the carrier was introduced at 1 and 3 mm short of the working length. The results of this study demonstrated that the distance of 3 mm short of the working length was safe to prevent extrusion, even in teeth with patency and at 700 rpm

rotation speed with any of the paste delivering techniques evaluated.

Our observations need to be interpreted with caution as *ex-vivo* experimentation cannot be regarded as directly representative of the clinical situation. Tissue pressure and resistance by the periapical tissues in the *in vivo* conditions may reduce the occurrence and extent of periapical extrusion of calcium hydroxide, although the exact effect of this variable is difficult to determine<sup>36</sup>.

There is a need for more comparative studies on the efficiency of the various Ca(OH)<sub>2</sub> delivering techniques in filling the root canal space in order to educate the clinician how to maximize the antimicrobial properties of Ca(OH)<sub>2</sub>, while avoiding the adverse effects caused by its extrusion into the periapical tissues.

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