

Comparative Evaluation of the Calcium Hydroxide Removing Ability from the Root Canals Among four file Systems, Namely, K File, ProTaper, ProTaper Next, and ProTaper Gold: An *in vitro* Study

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Abstract

Background: The aim of present study is to comparatively evaluate the calcium hydroxide removing ability from the root canals among four file systems, namely, K file, Protaper, Protaper Next, and Protaper Gold (PTG). **Methods and Materials:** Forty single-rooted teeth chosen for study. Marking made at 12 mm from the Apex for standardization of length. Decoronation of samples done. Biomechanical preparation of sample using hand K-Flex files, Protaper Universal (PTU) File, Protaper Next File, and PTG File was done. Placement of intracanal calcium hydroxide dressing in all prepared samples done. Intraoral periapical radiograph of sample was taken. Longitudinal sectioned sample of tooth was done and samples viewed under Stereomicroscope. **Results:** The data for the present study were entered in the Microsoft Excel 2010 and analyzed using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation, and percentages. The level of the significance for the present study was fixed at 5%, that is, $P < 0.05$. In concordance with overall results in our study, PTG displayed a better removal of calcium hydroxide than PTU and K-file followed by ProTaper Next from the middle and apical third of the roots. Moreover, the removal of calcium hydroxide from middle and apical third of the root showed almost nearly the same outcome. **Conclusion:** Under the conditions of this study, it was concluded that in middle third of the root PTG file system showed an effective removal of calcium hydroxide when compared to ProTaper Next, PTU, and K-file system.

Keywords: Calcium hydroxide, Hand files, Protaper, Stastical analysis.

INTRODUCTION

The main goal of endodontics is the complete elimination of bacteria from the root canal system. With the routine endodontic procedures followed, it is impossible to shape and clean the root canal completely.^[1] This could be because of the complex root canal anatomy that includes the presence of apical deltas, oval extensions, and isthmus.^[2,3] To remove microorganisms from an infected root canal system, the use of intracanal medicament is particularly indicated in non-vital teeth.^[4]

Intracanal medicament is an agent that is used in the root canal with an intended pharmacological action. Intra-canal medicaments are used to improve the disinfection of the root canal by the following ways,^[5]

- Eliminate any remaining bacteria after root canal instrumentation

- Reduce inflammation of periapical tissues and pulp remnants
- Render canal contents inert and neutralize tissue debris
- Act as a barrier against leakage from the temporary filling
- Dry persistently wet canals.

To overcome the difficulties in root canal preparation, simplify the procedures, and reduce its preparation time, several

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rotary systems have been developed and improved in the last few years, with the development of new rotary file designs, techniques, and manufacturing methods.^[6] Nickel-titanium (NiTi) instruments, characterized by their super-elastic behavior, shape-memory property, and lower modulus of elasticity compared to stainless steel files, prove to be more efficient and conservative in shaping narrow and curved root canals than stainless steel instruments.^[7]

A more recent and advanced metallurgy process allowed the manufacturer to introduce ProTaper Gold (PTG) rotary files, a more flexible NiTi instrument. This system features identical geometric characteristics as ProTaper Universal (PTU), with a triangular cross section and a variable progressive taper. PTG is manufactured by proprietary metallurgy that reportedly increases its flexibility and its resistance to cyclic fatigue^[8] and maintain canal centering, especially when preparing curved canals.^[9]

Therefore, this study is an effort to comparatively evaluate the calcium hydroxide removing ability from the root canals of four file systems namely K File, ProTaper, ProTaper Next, and PTG.

MATERIALS AND METHODS

The study was conducted in the Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Prabhu Dayal Memorial University, Bahadurgarh, Haryana.

Study setting

The study was conducted on 40 extracted permanent maxillary and mandibular single rooted teeth collected from Department of Oral and Maxillofacial Surgery, Faculty of Dental Sciences, Prabhu Dayal Memorial University, Bahadurgarh, Haryana.

Criteria for selection

Inclusion criteria

The following criteria were included in the study:

1. Intact single-rooted permanent teeth
2. Teeth with single and straight canal.

Exclusion criteria

The following criteria were excluded from the study:

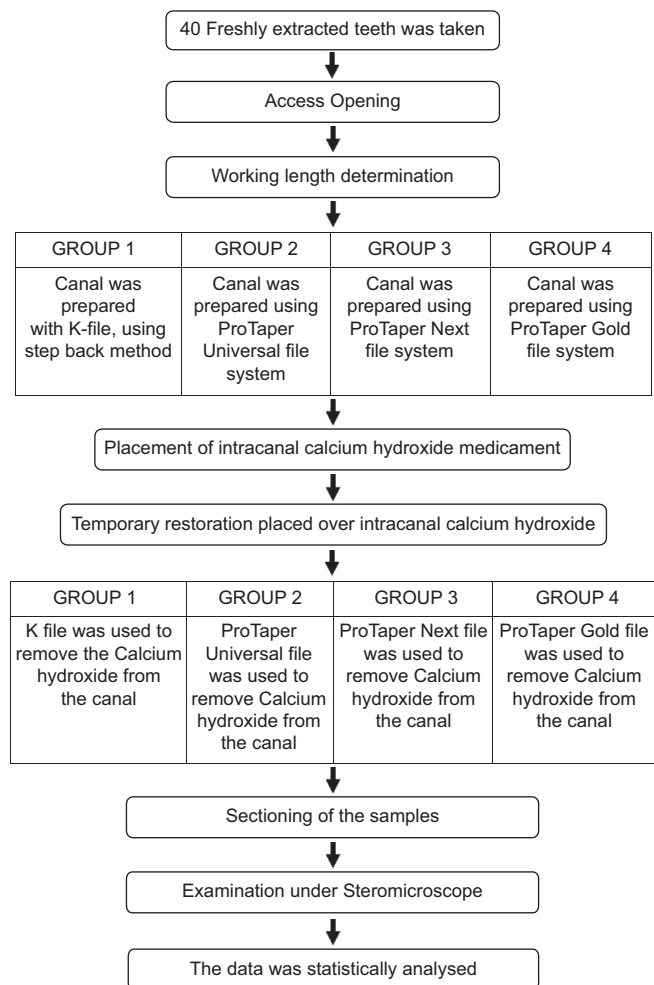
1. Teeth with resorptive defects
2. Root caries
3. Open apex
4. Root canal-treated teeth
5. Root calcification.

Study design

Materials and armamentarium

Distilled water, 10% formalin, 15 cm metal scale, Diamond coated disc with mandrel, Straight handpiece, Airtor hand piece, Endo access burs, K- file no. 15, Hand K flex files, PTU files, ProTaper Next files, PTG files, and Calcium hydroxide.

Temporary restoration, 3% Sodium hypochlorite, Normal saline, Disposable syringes, Paper points, Endo motor, Radiography (RVG), and Stereomicroscope.



Methodology

Collection of extracted teeth

Freshly extracted permanent single-rooted teeth were collected from the Outpatient Department of Oral and Maxillofacial Surgery department from Prabhu Dayal Memorial University Dental College and Research Institute, Haryana, India. Following extraction, teeth were washed thoroughly under running water and cleaned with ultrasonic instruments. Thereafter, they were disinfected with 3% Sodium hypochlorite. RVG of each tooth will be taken individually. This study included 40 teeth that were free of root fractures, root canal treatment, resorption, severe root curvature or calcification, caries, or other defects.

Scoring

The marked middle and apical portion were evaluated as per the following scores:

- Score (1) = Absence of remnants
- Score (2) = Scattered remnants
- Score (3) = Mass remnants
- Score (4) = Densely packed remnants.

All the images were evaluated in the middle and apical regions and thus the root length of 12 mm was equally divided into

three equal parts of 4 mm each. Both the halves of the samples were evaluated and the highest score was considered.

OBSERVATION AND RESULTS

A total of 40 teeth selected for the study were divided into four groups 1, 2, 3 and 4 comprising of 10 teeth in each group with single blind randomization based on the different file systems.

In the Group 1, teeth were prepared manually using step-back technique, in the Group 2, teeth were prepared with PTU file system, in the Group 3, teeth were prepared with ProTaper Next rotary file and in the Group 4, teeth were prepared with PTG rotary file. Ca(OH)₂ was placed. Canals were filled with Ca(OH)₂ paste and were sealed. After 7 days, Ca(OH)₂ was removed, using the same file system as that used for BMP. Samples were sectioned longitudinally and evaluated under a stereomicroscope based on the residual Ca(OH)₂ at middle and apical portion of the root in each group.

The residual calcium hydroxide at middle and apical portion of the root in each group was evaluated as per the following score:

Score (1) = Absence of remnants Score (2) = Scattered remnants Score (3) = Mass remnants

Score (4) = Densely packed remnant.

Table 1 depicts the distribution of the residual calcium hydroxide in the middle and the apical third of the root. The mean and standard deviation of residual calcium hydroxide in the middle third using K-File, PTU, ProTaper Next, and PTG were 3.20 ± 0.632 , 2.30 ± 0.483 , 2.10 ± 0.316 , and 1.10 ± 0.316 , respectively. The minimal amount of residual calcium hydroxide was present at middle portion using PTG, followed by ProTaper Next, PTU, and K-File. The maximal amount of calcium hydroxide was present using K-file, followed by PTU, ProTaper Next, and PTG shows the least. There was a statistically significant difference found in the mean residual calcium hydroxide scores of the four study groups at the middle third ($P = 0.000$).

The mean and standard deviation of residual calcium hydroxide in the apical third using K-File, PTU, ProTaper Next, and PTG were 3.70 ± 0.483 , 3.10 ± 0.738 , 2.50 ± 0.527 , and 1.60 ± 0.516 , respectively. The minimal amount of residual calcium hydroxide was present at apical portion using PTG, followed by ProTaper Next, PTU, and K-File. The maximal amount of calcium hydroxide was present using K-file, followed by PTU, ProTaper Next, and PTG show the least. There was a statistically significant difference found in the mean residual calcium hydroxide scores of the four study groups at the apical third ($P = 0.000$).

Statistical analysis

The data for the present study were entered in the Microsoft Excel 2010 and analyzed using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation, and percentages. The level of the significance for the present study was fixed at 5%, that is, $P < 0.05$.

The distribution of the study groups and intergroup comparison of residual calcium hydroxide percentages at middle and apical third of the root were performed using the Chi-square test and pairwise intragroup comparison among the four study groups at middle and apical third of the root were evaluated using Mann-Whitney U test.

Chi-square is a statistical test commonly used to compare observed data with data we would expect to obtain according to a specific hypothesis. When an analyst attempts to fit a statistical model to observed data, he or she may wonder how well the model reflects the data. How “close” are the observed values to those which would be expected under the fitted model? One statistical test that addresses this issue is the Chi-square goodness of fit test. This test is commonly used to test association of variables in two-way tables, where the assumed model of independence is evaluated against the observed data.

If the computed test statistic is large, then the observed and expected values are not close and the model is a poor fit to the data.

Table 1: Distribution of residual calcium hydroxide in middle and apical third of the root using Chi-square test

Root canal part	n	Mean	SD	Std. Error	95% confidence interval for mean		Chi-square	P-value
					Lower bound	Upper bound		
MIDDLE								
K-file	10	3.20	0.632	0.200	2.75	3.65	30.109	0.000*
ProTaper Universal	10	2.30	0.483	0.153	1.95	2.65		
ProTaper Next	10	2.10	0.316	0.100	1.87	2.33		
ProTaper Gold	10	1.10	0.316	0.100	0.87	1.33		
Total	40	2.18	0.874	0.138	1.90	2.45		
APICAL								
K-File	10	3.70	0.483	0.153	3.35	4.05	26.200	0.000*
ProTaper Universal	10	3.10	0.738	0.233	2.57	3.63		
ProTaper Next	10	2.50	0.527	0.167	2.12	2.88		
ProTaper Gold	10	1.60	0.516	0.163	1.23	1.97		
Total	40	2.72	0.960	0.152	2.42	3.03		

*Statistically significant ($P < 0.05$)

The Mann–Whitney U test is a non-parametric test that can be used in place of an unpaired t-test. It is used to test the null hypothesis that two samples come from the same population (i.e., have the same median) or alternatively, whether observations in one sample tend to be larger than observations in the other. Although it is a non-parametric test, it does assume that the two distributions are similar in shape.

DISCUSSION

The success of root canal treatment not only depends on instrumentation but also on irrigants and intracanal medicaments which are used during treatment to eradicate microorganisms from root canal system. The commonly used intracanal medicament is Ca(OH)₂ because it is highly active against pathogenic microflora present in the infected root canal.^[10]

Before obturation of root canal, Ca(OH)₂ should be completely removed to allow maximum bonding between canal walls and root canal sealer. Inadequate removal of Ca(OH)₂ medicament from root canal walls adversely affects the prognosis of root canal treatment. Since it may interact with the sealer and form unstable matrix.^[11] Zinc oxide eugenol-based sealers are the most commonly used because of their satisfactory physicochemical properties.^[12] Kuga *et al.*^[13] reported that residual Ca(OH)₂ may interact with zinc oxide eugenol sealer and result in calcium eugenolate formation. These residues might also affect the adhesion of sealer to root canal wall. Sealing ability of silicon-based sealer is also affected by the residual Ca(OH)₂.

Calcium hydroxide was chosen for this study because of its favorable alkalinizing effect. It has high pH of 12.5 and is only slightly soluble in water with a solubility of 1.2 g/l, at a temperature of 25°C.^[14]

In the present study, oil-based calcium hydroxide with iodoform is used. Oil-based preparation of Ca(OH)₂ is more difficult to remove than Ca(OH)₂ powder mixed with saline. The latter tends to release higher amount of hydroxyl ions within a short span of time whereas former although effective for a longer duration tends to release lower concentration of hydroxyl ions, leading to diminished clinical effectiveness.^[15]

Several methods and devices have been proposed over the years for activation of intracanal solutions to improve the mechanical flushing action of irrigant. Sonic, Ultrasonic, Canal brush, Files, etc. have been used for agitation of irrigating agents. Kenne *et al.*^[16] found rotary instrumentation and ultrasonic, better than hand instrumentation for removal of Calcium hydroxide. The mechanical agitation provided by ultrasonic/sonic instrumentation or a rotary file together with irrigants also enhance the removal of Calcium hydroxide. In the present study, we have used different rotary techniques namely PTU, ProTaper Next, and PTG along with K-File to remove the residual calcium hydroxide from the middle and apical portions of the root.

Various methods are used to determine the amount of Ca(OH)₂ residues present on the canal walls, such as digital imaging software, stereo microscopes, scanning electron microscopes, microtomography computed tomography (micro-CT), spiral CT, and cone beam CT.^[17] However, in the present study, remnants of Ca(OH)₂ on root canal walls were evaluated using Stereo microscope to know the efficacy of the instrumentation also.

In our study, PTG was found to be most effective in removal of Ca(OH)₂ whereas K file was least effective at the middle and apical thirds of the root. Furthermore, there was a statistically significant difference found in the percentage of residual calcium hydroxide among the four study groups at the middle and apical thirds of the root (Table 1).

The PTG has a convex triangular cross-section and a progressive taper. It also has a non-cutting tip, allowing the instrument to follow the original shape of the root canal, emphasizing its flexibility and less resistance. It has also been metallurgically improved through heat treatment technology. Due to this flexibility, it can help in the removal of calcium hydroxide from the canals.

After PTG, effective removal of calcium hydroxide from both the middle and apical thirds of the root occurred with ProTaper Next and were statistically significant among all groups in the present study (Table 1). The ProTaper Next rotary file is made of M-Wire NiTi with a rectangular cross-section and has achieved the best results in cyclic fatigue strength. ProTaper Next has a positive rake angle that improves cutting efficiency, a variable taper along its length, a balanced pitch, and a helix angle to prevent the screw effect, which can contribute improved effectiveness in removing oily Ca(OH)₂ from the canal. The manufacturer's recommended speed of ProTaper Next is 300 rpm and a torque of 200 g/cm.

In our study, PTU showed worse performance as far as removal of calcium hydroxide in the middle and apical thirds of the root were observed. The results were found statistically significant when compared to the group in which K file was used (Table 1 and Figure 1).

In the present study, among the groups, K-File was least effective in removing calcium hydroxide from the middle and apical third of the root. It showed statistical significant results

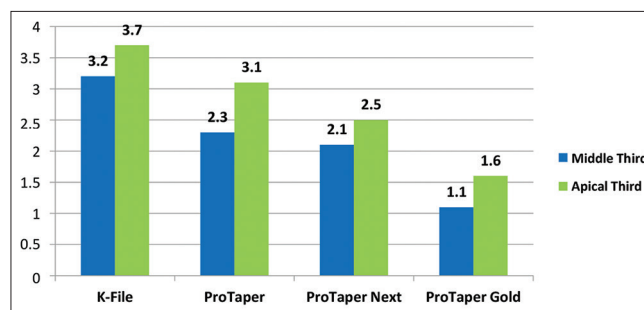


Figure 1: Mean residual calcium hydroxide scores in the middle and apical third of the root

when compared to other groups (Table 1). This could be due to the fact that the K-files lack especially the stiffness as well as the design of the tips.

Few other studies showed that In this study, all of the tested techniques resulted in highly effective removal of Ca(OH)₂ from the straight portion and coronal curvature of the S-shaped root canal. This finding is in agreement with the previous studies, which could be attributed to the larger diameter in these areas, exposing dentin to a higher volume of irrigants and making Ca(OH)₂ removal easier. However, none of the protocols could completely remove Ca(OH)₂ from the apical curvature. It remains difficult for the current irrigation techniques to remove the intracanal medicaments from the apical part of the root canal.

CONCLUSION

Under the conditions of this study, it was concluded that in middle third of the root PTG file system showed an effective removal of calcium hydroxide when compared to ProTaper Next, PTU, and K-file system. In the apical third of the root PTG file system showed an effective removal of calcium hydroxide when compared to ProTaper Next, PTU, and K-file system. Analysis of the middle and apical thirds of the root displayed significant differences among the PTG, ProTaper Next, PTU, and K-file systems.

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