A comparative in-vitro evaluation of debris removal using different rotary instrument files systems

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Abstract

The aim of this study was to evaluate & compare the cleaning efficacy of teeth instrumented with three different rotary instrumentation systems. The three file systems used in this study were Protaper Next, Hero Shaper and K3 File System. Thirty-three extracted, single-rooted human mandibular premolar teeth were selected and divided into three groups of 10 teeth each. Three teeth were used as negative controls. In group 1, teeth were prepared with Protaper Next File system while in group 2 and group 3 teeth were prepared with Hero Shaper File System and K3 File System respectively. Teeth were longitudinally sectioned and each half was further divided into three parts that is the coronal, middle and apical third and each third was evaluated at a magnification of 40X under stereomicroscope. SEM evaluation of the same was done under 500X. Based on the stereomicroscopic analysis of specimens, it can be concluded that in the apical third of root canal system cleaning efficacy was significantly higher for Protaper Next and K3 file system as compared to Hero Shaper file system while based on the SEM analysis of specimens, it can be concluded that in the coronal, middle and apical third of root canal system, cleaning efficacy was significantly higher for the K3 file system as compared to Hero Shaper file system.

Introduction

The primary objective of root canal instrumentation is the removal of vital and necrotic pulp tissue, infected dentine and dentine debris to eliminate most of the microorganisms from the root canal system (European Society of Endodontology 1994, American Association of Endodontists 1998). Debris is the dentin chips, pulp remnants, and particles loosely attached to the root canal wall[(1)]. The apical thirds of the root canal system are always most difficult to clean due to complex anatomies present like deltas, lateral canals, isthmuses, and ramifications[(2)].

In spite of the advancements in instruments and instrumentation technology, the inherent design limitations of the endodontic instruments leads to inadequate cleaning of the root canal system. Canal preparation techniques can be completed more efficiently, faster and predictably using NiTi rotary instruments, but proper cleansing of the root canal system, especially in the apical one-third, has not yet been demonstrated[(2-4)]. The cleaning capacity of various NiTi rotary systems varies because of the different cross-sections and blade designs of each system[(5-6)].

Three new file systems are used in this study. The ProTaper Next file system (Dentsply Maillefer, Ballaigues, Switzerland) having an off-centered rectangular design and progressive and regressive percentage tapers on a single file decreases the effect of the screw and dangerous taper lock by minimizing the contact between the file and the dentin. The offset design helps remove debris out of the canal compared with an instrument with a centered mass and axis of rotation[(7)].

Hero Shaper File System (Micro-Mega, Besancon, France), developed in 2001 has a specialized leading edge that during manufacturing has been purposely dulled to reduce the screwing-in action. Its name is HERO Shaper® for body shaping with "adapted pitch" concept & HERO Apical® for finishing apical root canal.[8]

K3 File System (Sybron Endo, Orange, CA) launched in 2002 has an overall design similar to that of HERO shaper file system with an added feature of unique cross-sectional design having a slightly positive rake angle for optimum cutting efficiency, extensive radial lands, and a peripheral blade relief for reduced friction.[9]

Aims and Objectives

The aim of this study is to evaluate and compare the cleaning efficacy of teeth instrumented with three different rotary instrumentation systems viz. Protaper Next File System (Dentsply Maillefer; Ballaigues, Switzerland), Hero Shaper File System (Micro-Mega, Besancon, France) and K3 File System (Sybron Endo, Orange, CA).

Null Hypothesis

No difference in cleaning efficacy of teeth instrumented with three different rotary instrumentation systems viz. Protaper Next File System (Dentsply Maillefer; Ballaigues, Switzerland), Hero Shaper File System (Micro-Mega, Besancon, France) and K3 File System (Sybron Endo Orange, CA).

Materials and Method

Materials

1. 33 Extracted Mandibular single rooted premolar teeth
2. Sodium Hypochlorite 3% and 5% (Prime dental products, India)
3. Liquid EDTA 17%
4. Normal Saline
5. K-files #10 and #15 (Mani INC, Tochigi, Japan)
6. Protaper Next File system (Dentsply, Maillefer, Ballaigues, Switzerland)
7. Hero Shaper File System (Micro-Mega, Besancon, France)
8. K3 File System (SybronEndo Orange, CA)
9. Irrigating syringe - 5 ml
10. Irrigating needle - 27 gauge
11. Sterile distilled water
12. Operating Microscope
13. Diamond disc
14. Chisel
15. Mallet

Methodology

Thirty-three extracted, single-rooted human mandibular premolar teeth with single root canal with completely formed roots were selected and placed in 3% sodium hypochlorite for 30 minutes and then stored in normal saline.

The extracted teeth were randomly divided into three groups of 10 teeth each. Three teeth served as negative controls in which no procedure was carried out. The teeth were then decoronated and their root lengths were standardized to 14 mm. Working lengths were taken 0.5mm short of the apical foramen using #10 K file. Teeth with the apical diameter larger than size 15 K-file were excluded from the study for standardization. Apical foramen was sealed using modeling wax.

Group 1: Teeth were prepared with Protaper Next File system (Dentsply, Maillefer, Ballaigues, Switzerland). The Pro Taper Next files were used in the sequence Pro Taper Next X1(0.17/0.04), X2(0.25/0.06), and X3(0.30/0.07), as per manufacturer's instructions.

Group 2: Teeth were prepared with Hero Shaper File System (Micro-Mega, Besancon, France). As the teeth selected in this study have straight roots, the blue sequence was followed for root canal preparation. First, the canal was instrumented to 2/3rd of the working length with a # 30/0.06 Hero Shaper file, followed by # 30/0.04 Hero Shaper file at working length, as per manufacturer's instructions.

Group 3: Teeth were prepared with K3 File System (Sybron Endo Orange, CA). Teeth were instrumented with 40/0.06 K3 File, followed by 35/0.06 K3 file, and finally #30/0.06 K3 file as per manufacturer's instructions.

In all the groups, teeth were irrigated 1 mm short of the working length with 2 ml of 5% sodium hypochlorite after the utilization of each instrument. At the completion of the instrumentation, each prepared canal was flushed with 5 ml 17% liquid EDTA for 60 seconds, followed by 5.25% sodium hypochlorite for 1 minute. After preparation and final irrigation, longitudinal sectioning of all the teeth was done according to Sabet et al[10]. Two longitudinal grooves placed on the outer surface of the roots and teeth were split in half longitudinally with a chisel and mallet. Each half was further divided into three parts that are the coronal third, middle third and apical third, and each third was evaluated under magnification of 40X under the stereomicroscope. SEM evaluation was done under 500X magnification.

Scoring for debris was done using Hulsmann criteria as follows.

Score I: Clean root canal wall, only a few small debris particles.

Score 2: Few small agglomerations of debris.

Score 3: Many agglomerations of debris covering less than 50% of the root canal wall

Score 4: More than 50% of the root canal wall covered by debris.

Score 5: Complete or nearly complete root canal wall covered by debris.

Statistical Analysis

All the data was analyzed and subjected to ANOVA test for comparing the three areas of the canal. P-Value was set at $p<0.05$

Results

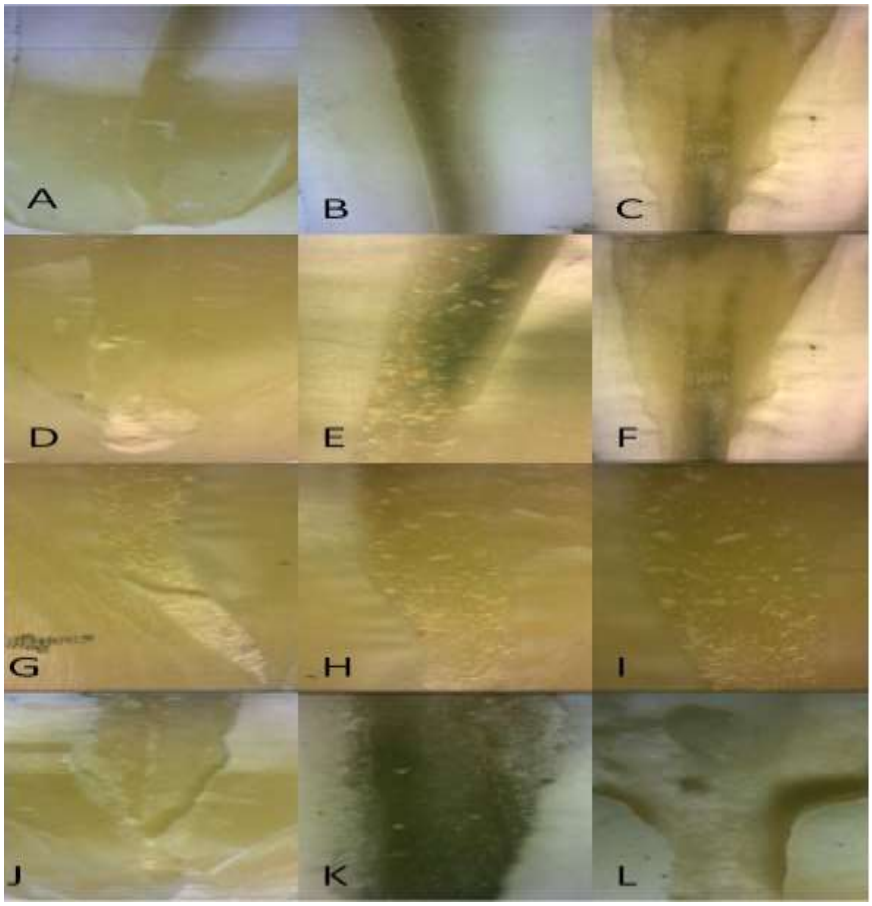

Fig. 1: Stereomicroscope Images (A- Apical Third Control Group, B- Middle Third Control Group, C- Coronal Third Control Group, D- Apical Third ProTaper Next E - Middle third ProTaper Next, F - Coronal third ProTaper Next, G - Apical Third Hero Shaper, H - Middle third Hero Shaper, I - Coronal third Hero Shaper, J - Apical Third K3, K - Middle third K3, L - Coronal third K3)

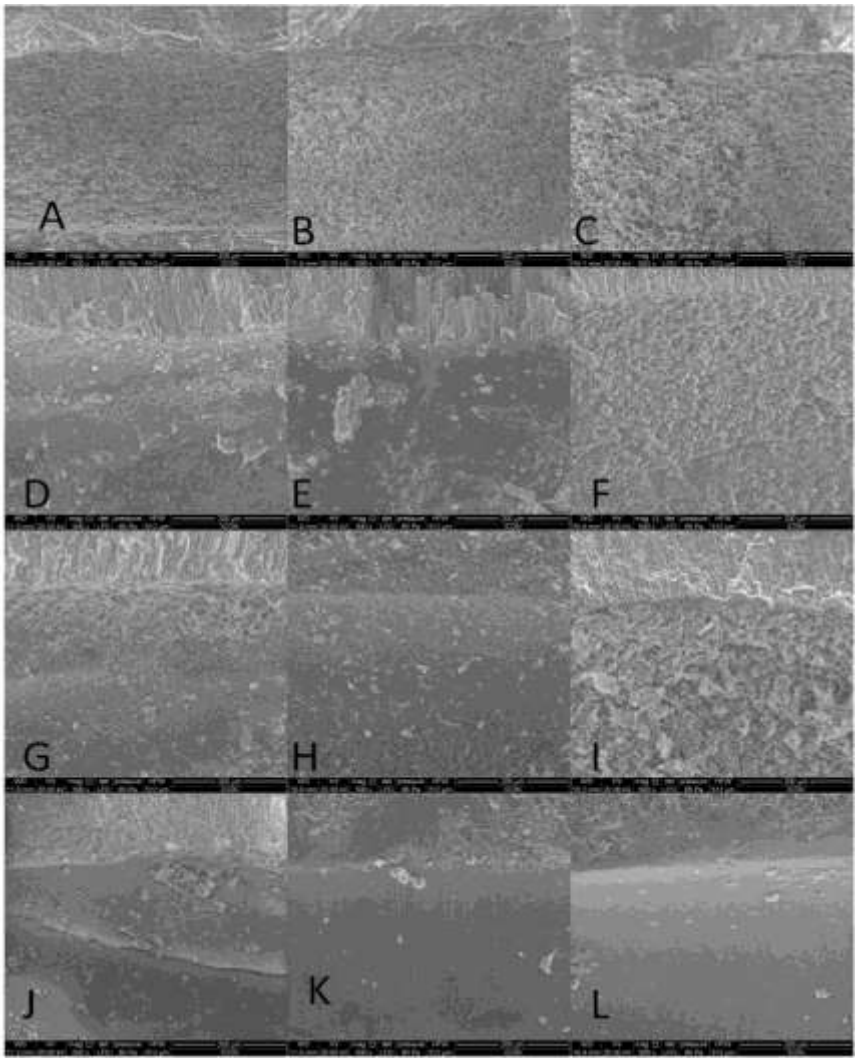

Fig. 2: Scanning Electron Microscope Images (A - Apical Third Control Group, B - Middle third Control Group, C- Coronal third Control Group, D - Apical Third ProTaper Next, E - Middle third ProTaper Next, F - Coronal third ProTaper Next, G - Apical Third Hero Shaper, H - Middle third Hero Shaper, I - Coronal third Hero Shaper, J - Apical Third K3, K - Middle third K3, L - Coronal third K3)

Table showing mean debris score in the three file systems

	Protaper Next	Hero	K3	Control	P Value*
Coronal	3.16	3.21	3.15	2.97	.966
Middle	2.87	2.97	2.73	1.73	.364
Apical	2.34[a]	3.64[b]	2.47[c]	1.67[d]	.025**

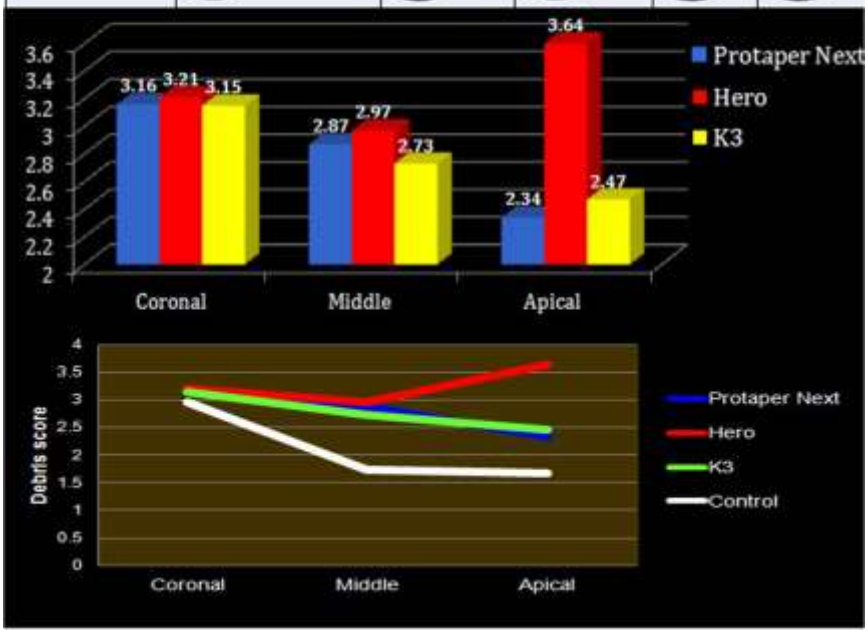

Fig. 3: Table showing mean debris scores (examination done under stereomicroscope 40X) (above) Graph showing Inter- Group comparison of mean debris score (below)

*P-value was set at P<0.05;

**Apical third values were statistically significant

Different alphabets as superscripts depict statistically significant difference across row

Table showing mean debris score in the three file systems

	Protaper Next	Hero	K3	Control	P Value*
Coronal	3.99	4.70[a]	2.60[b]	1.87[b]	.003*
Middle	2.96	3.47[c]	1.90[d]	1.87	.013*
Apical	2.87	3.24[e]	1.89[f]	1.87	.024*

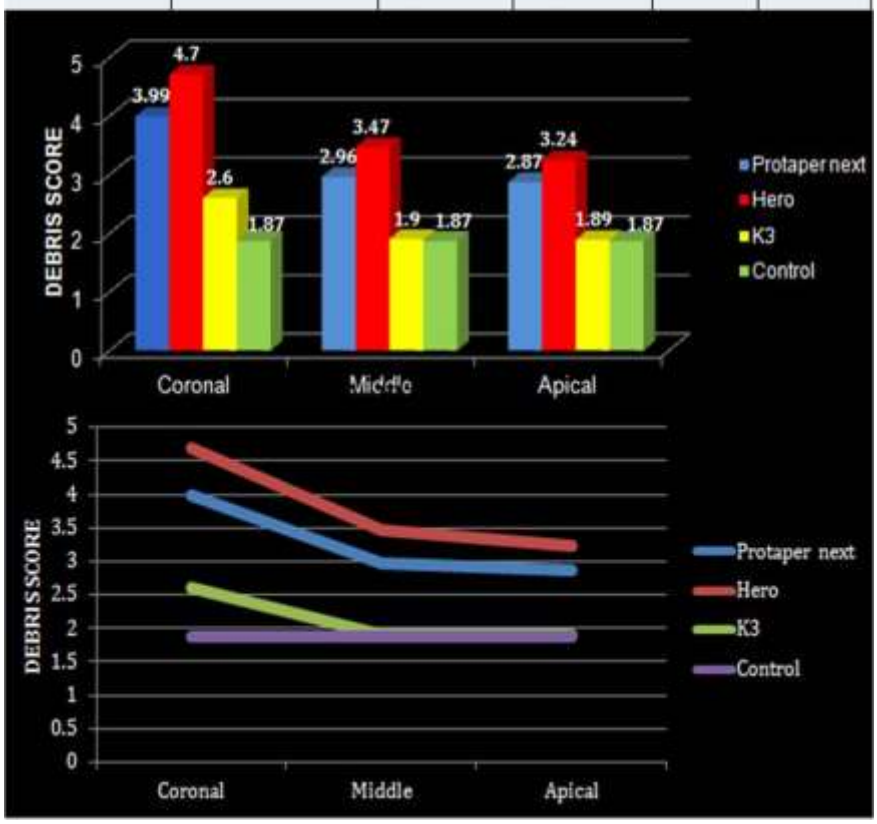

Fig. 4: Table showing mean debris scores (examination done under SEM 500X) (above) Graph showing Inter- Group comparison of mean debris score (below)

*P-value was set at P<0.05;

Different alphabets as superscripts depict statistically significant difference across row

In the stereomicroscope evaluation, control group showed least debris score in coronal, middle and apical third. Protaper Next had debris scores of 3.16, 2.87 and 2.34 in coronal, middle and apical third respectively. Hero Shaper file system had debris scores of 3.21, 2.97 and 2.64 in coronal, middle and apical third respectively while K3 file system had scores of 3.15, 2.73 and 2.47 in coronal, middle and apical third respectively.

When the same specimens were seen under scanning electron microscope and evaluated, control group showed least debris score in coronal, middle and apical third. Protaper Next had debris scores of 3.99, 2.96 and 2.87 in coronal, middle and apical third respectively. Hero Shaper file system had debris scores of 4.70, 3.47 and 3.24 in coronal, middle and apical third respectively while K3 file system had scores of 2.60, 1.90 and 1.89 in coronal, middle and apical third respectively.

Discussion

The primary purpose of root canal instrumentation is to shape and clean the root canal systems. The cleaning concept includes the removal of infected dentin and organic tissue by instrumentation and irrigation. File designs, rotational speed, different sequences of

instrumentation and surface conditioning of the instruments are important factors for efficient instrumentation in root canals. All endodontic instruments create debris and smear layer as a consequence of their action on the root canal walls.[11] This debris may be compacted along the surface of canal wall and prevents the efficient removal of microorganisms from the root canal system, one of the fundamental purposes of thorough debridement of the root canal system, [12] increasing the risk of bacterial contamination. Moreover, debris may occupy part of the root canal space, preventing complete obturation of the root canal.[13] Therefore, debris should be entirely removed.

In the present study, the scanning electron microscope (SEM) has proved to be a valuable method in the comparison of the remaining debris and smear layer on root canal wall after preparation with different instruments.[11,14] Therefore, the purpose of the present study was to compare by means of SEM the debris and smear layer remaining on canal walls and also the cleaning efficiency was examined on the basis of a numerical evaluation scheme for debris, by means of a Stereomicroscope evaluation of the coronal, the middle and the apical parts of the canals.

Within the limitations of this study it was found that according to Stereomicroscope analysis, Protaper Next and K3 file system had better cleaning efficacy (lower debris score) in the apical third as compared to Hero shaper. According to Scanning Electron Microscope analysis, K3 file system showed statistically significant lower debris score as compared to Hero shapers.

These results are as per the other previous studies where Hero 642 files have been reported to remove more dentin than K3 files[15], and K3 files are associated with greater remaining dentin thickness compared with some instruments[(16,17)]. González-Rodrguez et al[(15)] reported that Hero 642 files removed a greater mean area of dentin compared with K3 files.

A similar study conducted by Guobin Yang et al. concluded the canals prepared with Pro Taper instruments showed smaller amounts of debris and smear layer remaining in the apical region than Hero shaper files.

Conclusion

Based on the stereomicroscopic analysis of specimens, it can be concluded that

1. In the apical third of root canal system cleaning efficacy was significantly higher for Protaper Next and K3 file system as compared to Hero shaper file system.
2. No statistically significant difference is seen between the three areas of the root canal system, coronal, middle & apical thirds within any of the groups tested.

Based on the SEM analysis of specimens, it can be concluded that

1. In the coronal third, middle third and apical of root canal system, cleaning efficacy was significantly higher for the K3 file system as compared to Hero shaper file system.
2. In the coronal third of root canal system, cleaning efficiency was significantly greater for control group as compared to Hero shaper file system.

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