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ORIGINAL RESEARCH

Comparison of the Remaining Dentin Thickness in the Root after Hand and Four Rotary Instrumentation Techniques: An *in vitro* Study

MS Rama Rao, Abdul Shameem, Rashmi Nair, Sureshbabu Ghanta, Rekha P Thankachan, Johnson K Issac

ABSTRACT

Aim: The aim of the present study was to compare the remaining dental thickness (RDT) in the mesiobuccal root of mandibular first molars at 3 and 7 mm from the anatomic apex after instrumentation with ProTaper, light speed LSX, K3 and M2 and to compare with that of K-files.

Materials and methods: In this study, 60 extracted, untreated human mandibular first molars with fully formed apices, with curvature less than 35° and no root resorption were used. Prepared specimens were cut horizontally at 3 and 7 mm short of anatomic apex. The least dentin thickness from canal to external root surface was observed under 3× magnification and recorded using Clemax measuring tool and the sections were reassembled. Group I—instrumentation with ProTaper, group II—instrumentation with K3, group III—instrumentation with Light Speed LSX, group IV—instrumentation with M2 and group V—instrumentation with K-files and RDT was measured.

Results: Results showed that group V removed lesser amount of dentin compared to all other groups while all the three instrumentation techniques removed almost equal amount of dentin apically.

Clinical significance: Cleaning and shaping of the root canal space involves the elimination of pathogenic contents as well as attaining a uniform specific shape. However, the RDT following the use of various intraradicular procedures is an important factor to be considered as an iatrogenic cause that may result in root fracture. To avoid this, newer rotary instruments are being introduced.

Keywords: Mandibular first molars, Dentin thickness, ProTaper, Light Speed LSX, K3, M2 and K-files.

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INTRODUCTION

The most important procedure for a successful endodontic treatment is the cleaning and shaping of the canal system. These involves the removal of pathogenic contents, such as pulp tissue, microorganisms, necrotic dentin and debris from the root canal system and attain a uniform taper to facilitate the obliteration of the prepared canal space. Several authors to stress the necessity of flaring the root canal during instrumentation. Presently, flaring of the coronal and middle third portion of the root canal is mandatory as this allows the removal of interferences permitting better access to the apical end, greater penetration of irrigation needle and penetration of spreader.[1,2]

However, first author to suggest that flaring the canals resulted in cutting away too much tooth structure.[3] The other authors found that most perforations and strippings occurred on the distal walls of mesial roots of mandibular molars or on the proximal walls of the buccal roots of maxillary molars. This area of stripping and perforation is known as 'danger zone'. In order to maintain the integrity of canal walls at their thin portion and reduces the possibility of root perforation or stripping Abou-Rasset et al developed a technique called 'anticurvature filing'.[4]

Root perforation is a possible consequence of flaring that result in treatment failure. Also, flaring the canal excessively to allow instrumentation with larger files decreases the dentin thickness, resulting in reduction of remaining dentin thickness, thus, increasing the possibility of vertical root fracture.[4] Thus, the remaining dentin thickness (RDT) is important because the amount of dentin remaining enables the endodontically treated teeth to resist fracture, so more the removal of dentin during instrumentation more is the potential for the tooth to fracture.[5,6] More recently, a progress in the instrument designs that include noncutting tips, radial lands, different cross sections and varying tapers have been developed to improve the efficiency.

The ProTaper system (Dentsply/Maillefer) developed Machtou, Ruddle and West was designed to allow high efficiency and flexibility with few numbers of files. The ProTaper system consists set of six instruments—three shaping files (Sx, S_1, S_2) and three finishing files (F_1, F_2, F_3). The shaping files used in crown-down procedure were characterized by increasing taper over the length of cutting blade. This allows controlled cutting in special section of instrumented root canal.[7,8]

The light speed system (Light Speed Technology) designed by Wildey and Senia recently introduced light speed LSX. The design of this instrument was not machined but stamped or coined into a spade shape. The design of the blade is such that it is a short cutting head with a pilot tip. This pilot tip restricts the instrument to the central axis of the canal consequently reducing the incidence of zipping and canal transportation.[9] As the rotary NiTi endodontic instruments are being widely used in endodontic practice, researches needed to investigate and test their efficiency and safety in clinical use. One of these safety measures is the amount of remaining dentin thickness at the danger zone and its influence on the incidence of perforation at this area.[10]

The aim of the present study was to compare the RDT in the mesiobuccal root of mandibular first molars at 3 and 7 mm from the anatomic apex after instrumentation with ProTaper, Light Speed LSX, K-files, K3 and M2.

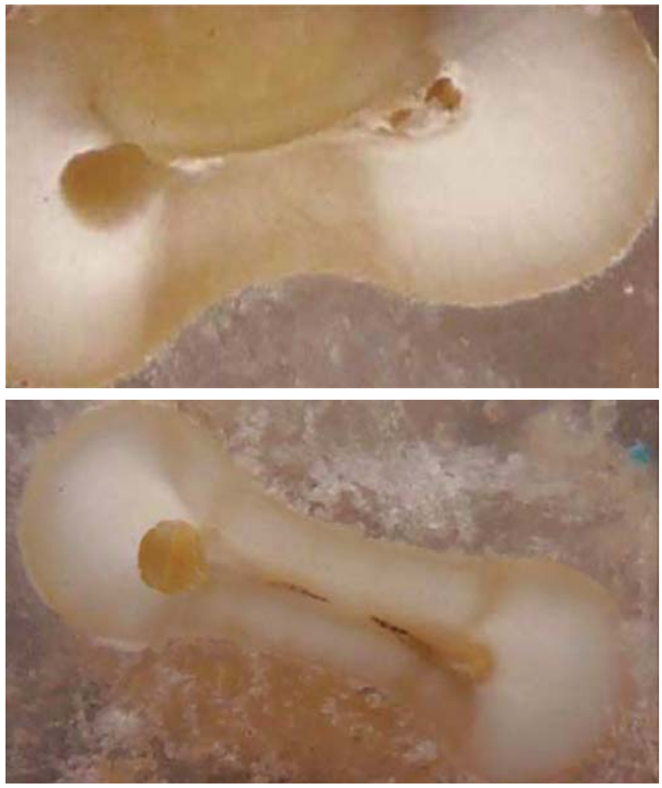

Fig. 1: Protaper (7 and 3 mm respectively)

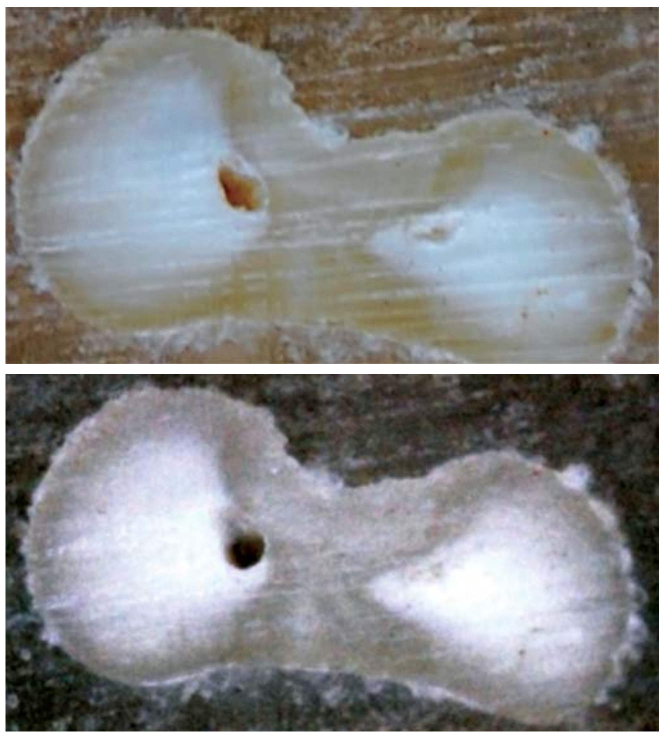

Fig. 2: K3 (7 and 3 mm respectively)

MATERIALS AND METHODS (FIGS 1 TO 5)

In this study, 60 extracted, untreated human mandibular first molars with fully formed apices, with curvature less than 35° and no root resorption were used. Teeth were stored in 10% buffered formalin solution. Endodontic access cavity prepared and the distal roots were removed. Working length was determined by passively introducing a No. 10 K-file into MB canals until visible at apical foramen and subtracting 1 mm.

The teeth were embedded in clear resin by using small cylindrical plastic molds. The tooth crown protruded to the level of cementoenamel junction and the roots were oriented parallel to the long axis of the mold. Then the autocuring acrylic clear resin was poured around the tooth to the level of cementoenamel junction. After the resin was completely set, it was released from the mold. Two holes 0.3 mm in diameter were drilled on either side of the tooth for the placement of bolts. Orientation grooves of about 2 mm deep was prepared with a low speed round bur along the surface of the block facing MB canal. The embedded roots were cut horizontally at 3 and 7 mm short of anatomic apex with a 0.3 mm thick blade mounted on a precision saw. Each section was seen under a stereomicroscope under

Fig. 3: Light speed (7 and 3 mm respectively)

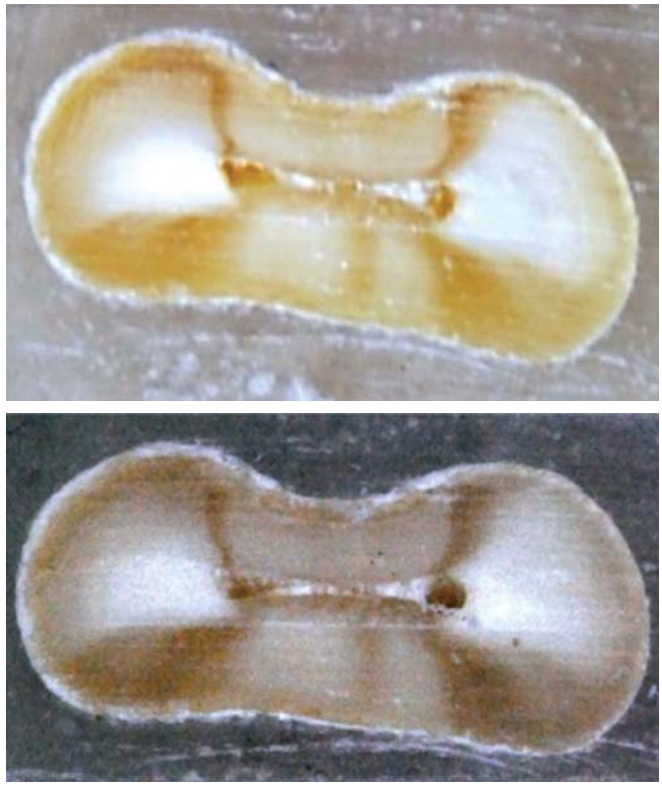

Fig. 5: K-file (7 and 3 mm respectively)

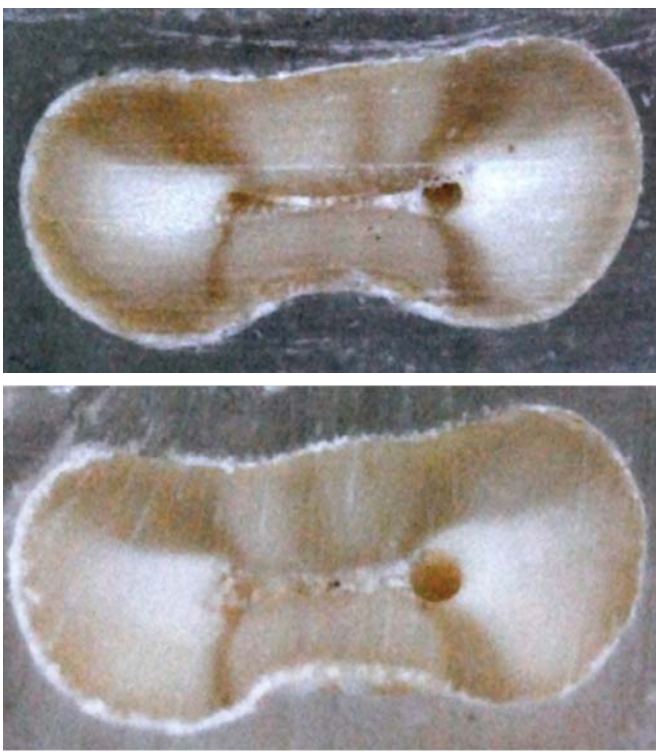

Fig. 4: M2 (7 and 3 mm respectively)

3× magnification and the least thickness from canal to external root surface recorded using a Clemax measuring tool. The sections were correctly reassembled according to orientation grooves and the two 0.3 mm bolts were inserted in the predrilled holes and secured with compatible nuts. Samples were subdivided into 6 groups; rotary instrumentation was done as per manufacturers' recommendation using endodontic micrometer (X Smart, Dentsply) the original dentinal width extending from the lumen of the root canal to the outer surface was measured at 3 and 7 mm from the apex using Clemax measuring tool.

Group I: ProTaper

S_1 was used till three-fourth of the working length. This was used to prepare the coronal part of root. Instrumentation with SX was done till coronal irregularities were removed. Shaping done with S_1 at working length followed by S_2, where S_2 was used to prepare the middle third of canal. The apical preparation was then done with F_1, F_2 and F_3 files. The speed was set at 300 rpm using 16:1 reduction.

Group II: K3

Root canals were prepared with the K3 system (SybronEndo, Glendora, CA, USA) with a constant speed of 250 rpm and 2.9 Ncm torque.

Group III: Light Speed LSX

Gates-Glidden No.2 was used for coronal preparation. For apical preparation, the first instrument to be used was determined by placing the instrument into the canal until resistance is met. Files # 20 and # 30 was used for this

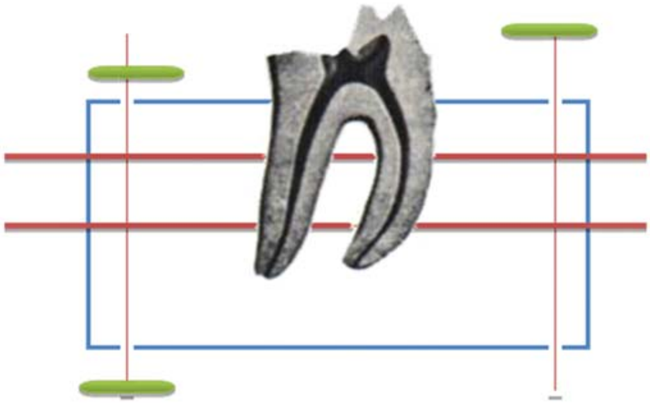

Fig. 6: Schematic diagram of Bramante technique

purpose and was termed initial apical rotary. Once the resistance was felt, pause was given at the resistance and then slowly pushed to working length. Next instrument was done similarly and this was continued to the next until a firm push was required, a # 45 in the case of this study. This was master apical rotary. In the middle third, the next bigger instrument was used short of 4 mm after which a 1 mm step back was done per instrument until resistance was felt coronally. Recapitulation was done with master apical rotary file. The speed was set to 2500 rpm using 4:1 reduction.

Group IV: M2

This new generation of NiTi rotary instruments was recently introduced in the European market by VDW, Munich, Germany. The standard set for this system includes four instruments with variable tip sizes ranging from #10 to #25, and tapers ranging from .04 to .06 (size 10/.04 taper, size 15/.05 taper, size 20/.06 taper, size 25/.06 taper. The sequence for groups instrumented with M2 was as follows: #10/04, #15/05, #20/06 and #25/06 were used to their full length in rotation with a gentle in-and-out motion (Fig. 6).

Group V: K-Files

Gates-Glidden No. 2 and 3 was used for coronal preparation K-files were used in watch winding motion, until working length is reached. Apical preparation was continued up to #35 K file after which step back was done with a reduction of 1 mm for each file until #55 K-file. Recapitulation was done following the use of each instrument.

The slices were separated and the remaining dentin thickness was measured. The average measurement was calculated and recorded.

RESULTS

The mean and SD of the remaining root dentin thickness are evaluated. The results were statistically analyzed by one-way ANOVA test analysis of variance of remaining root dentin thickness showed significant difference among the groups.

The mean (±SD) RDT of the MB canal both pre- and postinstrumentation and different levels of the root is presented in Table 1.

DISCUSSION

When a new root canal instrument with a unique design is introduced, several characteristics need to be investigated and tested to allow an efficient and safe clinical usage.[11] Many techniques were utilized to compare the effectiveness of different instrumentation techniques in preparing root canals including plastic blocks,[12] radiographic techniques[13] and scanning electron microscope to study histological sections.[14] A nondestructive technology using micro-computed tomography has been advocated for the comparison of pre- and postinstrumentation images.[15] The most popular methods of evaluation was the use of Bramante muffle block system which was used in this study (Z).[16] This method was relatively simple and economical but the space created among slices during sectioning resulted in loss of tooth structure and working length. This was however, overcome by compensating with the disks that were placed (Zp).

The diameter and remaining dentin thickness of the canal dictates the mechanical limit of instrumentation so as not to weaken the dentinal walls. Studies have shown that in the first mandibular molars, 1.5 mm below the bifurcation the real thickness of the dentin is the least of about 1.2 to

Table 1: Level in millimeter from working length

Groups	*7 mm*			*3 mm*		
	Pre	*Post*	*Diff*	*Pre*	*Post*	*Diff*
ProTaper	1.18 ± 0.5	0.95 ± 0.15	0.23	1.13 ± 0.11	1.02 ± 0.05	0.11
K3	1.17 ± 0.8	1.01 ± 0.14	0.16	1.14 ± 0.10	1.02 ± 0.13	0.12
Light Speed LSX	1.13 ± 0.11	1.12 ± 1.05	0.01	0.8 ± 0.11	0.54 ± 0.12	0.42
M2	1.23 ± 0.12	1.10 ± 0.13	0.13	1.12 ± 0.12	1.02 ± 0.8	0.10
K-files	1.4 ± 0.1	1 ± 0.1	0.4	1.17 ± 0.13	1.00 ± 1.11	0.17

Pre: Preinstrumentation; Post: Postinstrumentation; Diff.: Difference

1.3 mm, the study reported that the middle third of the mesial root of the mandibular first molar has a distal surface concavity with a root thickness of 0.7 ± 0.19 mm. Thus, the mandibular molars are easily subjected to perforations. The average wide diameter in apical 1 to 2 mm in mesial canal was found to be 0.30 to 0.40 mm. In addition to perforations, preparation of the apical third using the higher grades of instruments could lead to reduction of the remaining dentin thickness, hence weaken the tooth structure.[17]

According to this study at 7 mm and 3 mm short of anatomic apex, i.e. toward the furcation level and in the middle third respectively, M2 removed lesser amount of dentin compared to all other instruments while apically 3 mm short of anatomic apex all the three instrumentation techniques removed almost equal amount of dentin.

The concept of cleaning canals using Light Speed LSX was by matching the final apical instrument size to that of the original apical canal size. The LSX begins to cut only when the blade touches two walls at the narrowest part of the oval canal, Though Gates-Glidden No. 2 was required to flare the coronal dentin, excessive flaring was not necessary as these flexible nontapered instruments has the advantage of approaching and preparing the apical third conservatively.

The files of the M2 system (VDW, Munich, Germany) feature an S-shaped cross-sectional design, a positive rake angle with two cutting edges, and increasing pitch length from the tip to the shaft. When comparing with other rotary systems this system has shown more shaping ability and cleaning efficiency in curved root canals.

ProTaper being a progressively tapering rotary instrument allows selective removal of coronal dentin permitting the instrument to advance toward apex at the same time removing substantial amount of dentin thus, reducing the remaining dentin thickness. Though larger sizes of K-files No. 45 to 50 were used in the apical region, Gates-Glidden No. 2 and 3 were used to flare the coronal dentin so as to permit the entry of these nonflexible instruments consequently causing excessive flaring and reducing significant amount of remaining dentin thickness.

CONCLUSION

According to this study, the following conclusions were drawn instrumentation with M2 does not reduces the RDT in middle and coronal third compared to other five rotary instrumentation techniques. All the six instrumentation techniques remove almost equal amount of dentin apically.

CLINICAL SIGNIFICANCE

Cleaning and shaping of the root canal space involves the elimination of pathogenic contents as well as attaining a uniform specific shape. However, the RDT following the use of various intraradicular procedures is an important factor to be considered as an iatrogenic cause that may result in root fracture. To avoid this, newer rotary instruments are being introduced.

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ABOUT THE AUTHORS

MS Rama Rao

Professor and Head, Department of Conservative Dentistry and Endodontics, Sree Sai Dental College and Research Institute Srikakulam, Andhra Pradesh, India

Abdul Shameem

Professor and Head, Department of Conservative Dentistry and Endodontics, MES Dental College, Malappuram, Kerala, India

Rashmi Nair (Corresponding Author)

Reader, Department of Conservative Dentistry and Endodontics Rungta College of Dental Sciences and Research, Bhilai, Chhattisgarh India, e-mail: rashmi.a.nair@gmail.com

Sureshbabu Ghanta

Professor and Head, Department of Oral Pathology, Vishnu Dental College, Bhimavaram. Andhra Pradesh, India

Rekha P Thankachan

Professor, Department of Conservative Dentistry and Endodontics MES Dental College, Malappuram, Kerala, India

Johnson K Issac

Professor and Head, Department of Oral Medicine and Radiology MES Dental College, Malappuram, Kerala, India