Future Dental Journal

Volume 7 | Issue 2 Article 4

2021

Evaluation of Remaining Dentin Thickness After Manual and Rotary Instrumentation In Primary Molars Using Cone Beam Computed Tomography. (An In-Vitro Study)

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Recommended Citation

Eldemery NA, Elshehawy O, Nasr RA, Badr MM. Evaluation of Remaining Dentin Thickness After Manual and Rotary Instrumentation In Primary Molars Using Cone Beam Computed Tomography. (An In-Vitro Study). *Future Dental Journal*. 2022; 7(2):95-98. doi: https://doi.org/10.54623/fdj.7024.

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Cover Page Footnote

I would like to express my gratitude, appreciation and thanks to Prof. Dr. Osama Ibrahim El-Shahawy, Professor and Head of Pediatric Dentistry and Dental Public Health, Faculty of Oral and Dental Medicine – Future University in Egypt. I do sincerely appreciate his guidance and supervision. It was a great honor and privilege to work and study under his supervision. I would like to express all my heartfelt thanks and sincere gratitude to Assoc. Prof. Rania Abdulla Nasr, Associate Professor of Pediatric Dentistry, Faculty of Dentistry- Cairo University, for her priceless and invaluable help. I am really thankful for her time, effort, and suggestions that have shaped this study. I would like to express my deepest thanks and sincere gratitude to Dr. Mahmoud Mohamed Badr, Lecturer of Endodontics, Faculty of Oral and Dental Medicine –Future University in Egypt, for his continuous support, cooperation, patience, and his precious time that he has given to every detail throughout the research. I want to thank Dr. Mona Ahmad Nour, Assistant Lecturer of Dental Radiology Department, Faculty of Oral and Dental Medicine -Future University in Egypt, for her help throughout the imaging process.

Future Dental Journal Volume 7, Issue 2 (2021) 95—98

Contents lists available at Arab Journals Platform

Future Dental Journal

Journal homepage: https://digitalcommons.aaru.edu.jo/fdj/

Evaluation of Remaining Dentin Thickness After Manual and Rotary Instrumentation In Primary Molars Using Cone Beam Computed Tomography. (An In-Vitro Study)

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ARTICLE INFO

Discipline:
Pediatric dentistry, Endodontics

Keywords:
Manual files,
Rotary files,
Remaining dentin thickness,
CBCT.

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ABSTRACT

Aim: To compare the radicular dentin thickness before and after instrumentation by manual stainless-steel (K-files) versus rotary files (AF™ Baby File) at coronal, middle, and apical thirds using Cone Beam Computed Tomography (CBCT).

Materials and Methods: Forty roots of extracted mandibular primary molars were collected, and randomly and equally divided into 2 groups. **Manual Group** was prepared by K-files, and **Rotary Group** was prepared by rotary AF™ Baby File system. Samples were decapitated and stabilized in epoxy resin blocks. Samples were subjected to CBCT scan before and after instrumentation for radicular dentin thickness evaluation at 3 measuring points; apical, middle, and coronal.

Results: An average amount of dentin removed was found to be significantly higher in Manual Group compared to Rotary Group in the 3 measuring points (P <0.005). ***Conclusion:*** Rotary files can be considered more preferable than manual files in terms of preservation of radicular dentin thickness after root canal instrumentation, therefore rotary files can be a suitable substitute for conventional SS manual files

1. INTRODUCTION

Conventionally, root canal instruments were manufactured using carbon steel and then replaced by stainless steel (SS). In 1980s nickel-titanium (NiTi) rotary instrumentation was introduced, which facilitates faster, efficient canal preparation with less iatrogenic errors[(1)]. Rotary instrumentation has been introduced to pediatric endodontics by Barr et al. in 2000 with the aim to preserve the root anatomy, the integrity and location of the canal, and the apical anatomy in preparation for an adequate filling[(2)(3)].

The residual dentin thickness (RDT) following intra-radicular procedures correlates to fracture resistance of the root. As 0.3 mm of dentin should be left after canal preparation to provide enough resistance against lateral forces. It was reported that pre-instrumentation canal wall thickness appeared to be the most significant factor in determining post-instrumentation canal wall thickness[(4)].

Cone-beam computed tomography (CBCT) is a modern noninvasive diagnostic method with compact equipment and low-dose radiation. It is valuable in comparing the root canal anatomy pre and post biomechanical preparation, which can help in determining the amount of RDT[(5)].

2. MATERIALS AND METHODS

2.1 Selection of Samples

A total of 40 roots of lower primary molars were selected after extraction for different clinical reasons. Teeth were collected from the out patients' clinic of the Pedodontics Department at Future University in Egypt.

Teeth were debrided by rinsing under running water and all periodontal fibers or soft tissues were removed using sharp hand scaler. All teeth were examined using a magnifying lens (6x) to accept or reject the sample based on the inclusion and exclusion criteria.

A-Inclusion Criteria:

- Mandibular primary molars.
- At least two-thirds of the root is intact.
- Moderate root angulation (20-40°).

B- Exclusion Criteria:

- Primary teeth with developmental defects.
- External and/or internal pathological root resorption.
- Presence of perforation in the internal and/or external furcation area

- Presence of root anomaly or calcified root canal.
- Root caries.

2.2. Sample Size Calculation and Distribution

A total sample size of 40 samples was sufficient to detect the effect size of 0.40, a power (1-β) of 80% and at a significant level of 5% ($p<0.001$), each experimental group would be represented by 20 samples.

2.3 Standardizing the Root Length

For the aim of standardization, all the selected roots were decapitated to standardize the root length (9 mm). This was done using a digital caliper, 9 mm was measured from the apex of the root to coronal direction. Then the tooth was fixed on a block using acrylic resin, for proper support during the sectioning procedure using *Linear Precision* diamond machine **(Figure-1)**. Length was confirmed by remeasuring the root sample **(Figure-2)**.

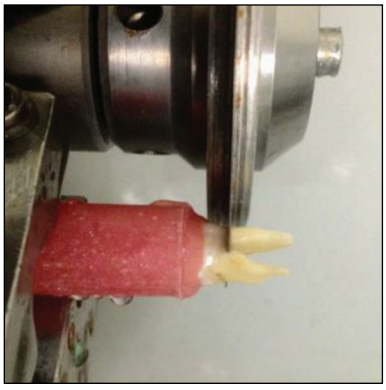

Figure (1) — Showing the root decapitation under copious irrigation.

Figure (2) — Showing the confirmation of 9mm root length after decapitation.

2.4 Grouping of the Specimens

For randomization, each root was assigned a number, from 1 to 40. All 40 numbers were written on pieces of paper and placed in a sealed envelope. Numbers were drawn by external examiner, afterward the respective root allocated to one of the two groups; Manual K-files (n = 20), and Rotary AF™ Baby File (n = 20).

2.5 Mounting of Samples

Teeth were mounted in epoxy resin blocks prior to scanning and preparation in order to maintain standardization of the specimens for the CBCT imaging before and after root canal instrumentation **(Figure-3).**

Figure (3) — Showing the Epoxy resin blocks.

2.6 Pre-instrumentation CBCT Scanning

CBCT examination by Vatech™ PaX-i3D Green imaging machine (Samsung 1-ro 2-gil, Hwaseong-si, Gyeonggi-do, Korea). Using the image protocol for each root with the following exposure parameters: voxel size: 0.075 mm, beam diameter: 5.5x5.

For determining the measuring points, the root length (9mm) was divided into thirds; apical third (0mm) to (3mm) from the apex, middle third (3mm) to (6mm) from the apex, and coronal third (6mm) to (9mm) from apex.

For standardization, each third was represented by a fixed mid-point. The radicular dentin thickness at the apical third was measured at 2mm from the apex, at middle third was measured at 4.5mm from the apex and at 7.5mm from the apex for the coronal third of the root canal **(Figure- 4)**

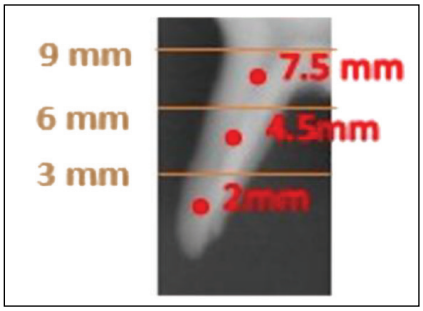

Figure (4) — Showing CBCT image of the 3 measuring points.

The distance from the internal aspect of the canal to the external aspect of the root was measured at 4 directions; mesial, distal, buccal, and lingual. The point of intersection of sagittal and coronal planes was considered as a reference point to determine the 4 directions as shown in (**Figure-5**).

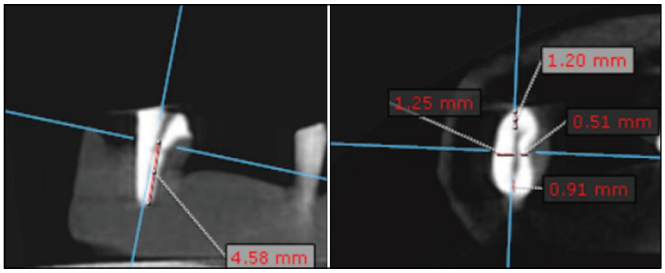

Figure (5) — Showing CBCT image of dentin thickness measurement at 4 directions (mesial, distal, buccal, and lingual) at 4.5 mm.

https://digitalcommons.aaru.edu.jo/fdj/vol7/iss2/4
DOI: https://doi.org/10.54623/fdj.7024

2.7 Root Canal preparation

The root canal preparation of all samples was conducted by a single operator under the guidance of a postgraduate supervisor.

All files were set to a working length of 8 mm, which is 1 mm shorter than the standardized root length (9mm).

Copious saline irrigation using irrigation needle with gauge size 27 was performed after using each file, to prevent canal blockage or clogging of the cutting flutes by the debris.

- Manual Group (n = 20): The root canals were manually prepared with SS K-files (MANI INC, Japan) in a step-back technique till file size #30.
- Rotary Group (n = 20): The root canals were instrumented using crown down technique with rotary 16-mm length AF™ Baby File (Fanta Dental Material Co., Shanghai, China). As per the manufacturer's recommendation, 4 files should be used sequentially in the following order; Open file, BTF1, BTF2, followed by BTF3. All rotary files were activated by an X-Smart IQ™ motor hand- piece (Dentsply Maillefer, Ballaigues, Switzerland) at speed 350 rpm and torque 2 N following the manufacturer's instructions and recommendations.

2.8 Post-instrumentation CBCT scanning

All samples were subjected to CBCT scanning after completion of root canal preparation, using the same scanning parameters and measuring points as the pre-instrumentation scanning.

Statistical Analysis

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests and the data that was showed was parametric (normal distribution). Two-way ANOVA was used to test the interaction between variables. The significance level was set at $P \leq 0.005$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

3. RESULTS

3.1 Residual Dentin Thickness

Statistical analysis showed that there was a statistically significant difference where (p<0.001) between (Before) and (After) instrumentation. The results showed that the Rotary group showed higher mean value of RDT at the 3 measuring points (apical, middle, coronal) **(Table-1)**.

Table 1:

Comparison of the mean, standard deviation (SD), & difference values of dentin thickness between Manual & Rotary groups at the 3 points (coronal, middle, apical)

Variables	Dentin thickness					
	Manual			Rotary		
	Coronal	Middle	Apical	Coronal	Middle	Apical
	Mean (mm)	Mean (mm)	Mean (mm)	Mean (mm)	Mean (mm)	Mean (mm)
Before	1.21 ±0.08	0.94 ±0.16	0.68 ±0.05	1.17 ±0.08	0.84 ±0.1	0.57 ±0.09
After	0.76 ±0.07	0.6 ±0.09	0.44 ±0.04	0.96 ±0.07	0.7 ±0.08	0.47 ±0.08
Difference	0.45	0.34	0.24	0.21	0.14	0.1
p-value	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***

**; significant (p<0.05) ns; non-significant (p>0.05)*

3.2 Percentage of Dentin Thickness Reduction

There was a statistically significant difference between (Manual) and (Rotary) groups in the percentage of dentin thickness reduction after instrumentation where (p<0.001). The highest mean value of percentage of reduction was found in (Manual) group, while the least mean value was found in (Rotary) group. The mean values and standard deviation of dentin reduction percentage at the 3 point (coronal, middle, apical point) of both groups are presented in **(Table-2).**

Table 2:

Mean and SD of Percentage of dentin thickness reduction between Manual and Rotary groups at 3 points (coronal, middle, apical).

Variables	Percentage of dentin thickness reduction					
	Coronal		Middle		Apical	
	Mean %	SD	Mean %	SD	Mean %	SD
Manual	37.43	2.47	36.50	3.85	35.37	5.84
Rotary	17.68	3.76	17.53	2.10	17.06	2.95
p-value	**<0.001***		**<0.001***		**<0.001***	

**; significant (p<0.05) ns; non-significant (p>0.05)*

4. DISCUSSION

The success of endodontic therapy is based upon the triad of thorough canal debridement, effective disinfection, and obturation of the canal space until optimum length[1,6]. Complex pulp morphology, in addition to the child's co-operation, make the primary teeth vulnerable to endodontic treatment failure[4]. The Current era of NiTi files in pulpectomy procedures indicate a paradigm shift in root canal treatment for primary teeth.

Preservation of radicular dentin thickness using a less invasive preparation approach is associated with better endodontic outcomes[7]. Therefore, the remaining radicular dentin following canal preparation may be the most important iatrogenic factor that correlates to fracture resistance of the root. It was firstly stated by Lim and Stock in 1987[8], that the minimum remaining thickness of canal walls after canal preparation should be 0.3 mm to allow adequate resistance against lateral and occlusal forces.

The insertion of SS instruments into curved root canals creates the tendency of reversing back to their straight shape due their shape memory property. This property leads to excessive removal of dentin in the outer surface of curvature. The NiTi instruments overcome this drawback by their high flexibility[9].

However, NiTi files have two to three times the elastic flexibility of SS files. The superior resistance of NiTi files to torsional fracture and their inherent ductility make these instruments more practical in the preparation of curved root canals[10]. NiTi instruments have exerted less force on the canal wall during preparation compared to their SS counterparts due to their triangular cross section.

The present study revealed that in all dimensions SS hand instrumentation removed more dentin than NiTi rotary AF™ Baby File instrumentation, which came in agreement with ***Manker et al.***[11], study findings.

A similar conclusion was reached by ***Musale et al.***[12] after they evaluated the percentage of dentin reduction after using manual (K-files) and rotary 0.04 Hero Shaper file system. But there was a difference in the average percentage of dentin reduction between the two studies, where Hero Shaper removed more amount of dentin than AF™ Baby File system. The justification behind this could be the difference of the file's cross section design. Cross-section

indicates the aggressiveness of the file, AF™ Baby file system has a triangular cross section, while Hero Shaper file is triangular with positive rake angle, and a smaller cutting angle, which makes Hero Shaper more aggressive.

Jayam et al.[13] compared the RDT after manual (K-file) and Kedo-S rotary pedodontic file system at 3 different measuring points along the root length (coronal, middle, apical) using CBCT. Their study results came with disagreement with the present study. As they concluded that there no statistically significant difference in reduction of dentin thickness between manual and rotary groups at the apical and middle thirds, however there was a significant difference represented only in the coronal third. The justification of the different results may be due to the difference in the file taper, as Kedo-S file has a variable taper that can reach up to 8%, while AF™ Baby file system has a constant taper of 0.04 ISO along the whole file length.

Although the current study showed that the rotary instrumentation is more preservative to radicular dentin than manual instrumentation, it can't be proven that it is able to remove all the infected dentin thickness since about 40-60% of the root canal walls remain un-touched even after mechanical instrumentation[14]. However, this pitfall can be overcome by the appropriate irrigation protocol which dramatically improves the cleanliness and disinfection of the entire root canal configuration system. Moreover, the action of the primary root canal filling material can aid the chemo-mechanical disinfection process. It is composed of calcium hydroxide paste containing 38% iodoform. It has a points antimicrobial action that helps in the disinfection process[15].

5. CONCLUSIONS

Within the experimental conditions and limitations of the present study, the following conclusions can be drawn:

1- Rotary files can be considered more preferable than manual files in terms of preservation of radicular dentin thickness after root canal instrumentation along the entire length of the root.

2- Rotary files can be a suitable substitute for conventional SS manual files.

3- The preservation of the radicular dentin by rotary instrumentation technique can be considered more respective to the anatomy of the thin radicular dentin thickness of primary teeth when measured at different point (apical, middle, coronal).

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https://digitalcommons.aaru.edu.jo/fdj/vol7/iss2/4
DOI: https://doi.org/10.54623/fdj.7024