A COMPARATIVE EVALUATION OF CUTTING EFFICIENCY OF MANUAL AND ROTARY FILE SYSTEM IN PRIMARY TEETH.

BABU BANARASI DAS UNIVERSITY, LUCKNOW

Thesis submitted in partial fulfilment of the requirements for degree of

MASTER OF DENTAL SURGERY

In the subject of

PEDIATRIC AND PREVENTIVE DENTISTRY

DEPARTMENT OF PEDIATRIC AND PREVENTIVE DENTISTRY

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES,

LUCKNOW, UTTAR PRADESH- 227105

BATCH- 2018- 2021

Dr. NUPUR

GUIDE: Dr. SOMYA GOVIL

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"A COMPARATIVE EVALUATION OF CUTTING EFFICIENCY OF MANUAL AND ROTARY FILE SYSTEM IN PRIMARY TEETH."** is a bonafide and genuine research work carried out by me under the guidance of **Dr. Somya Govil**, **Reader,** Department of Pediatric and Preventive Dentistry, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

Date: 07/07/21

Place: Lucknow

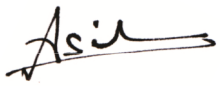
Nupur

Dr. NUPUR

CERTIFICATE

This is to certify that the dissertation entitled **"A COMPARATIVE EVALUATION OF CUTTING EFFICIENCY OF MANUAL AND ROTARY FILE SYSTEM IN PRIMARY TEETH."** is an original bonafide research work done by **Dr. NUPUR,** in partial fulfilment of the requirement for the degree of **MASTER OF DENTAL SURGERY (M.D.S)** in the speciality of **PEDIATRIC AND PREVENTIVE DENTISTRY** under our supervision.

GUIDE
Dr. Somya Govil
M.D.S
Reader



CO-GUIDE
Dr. Atul Singh
M.D.S
Reader

Department of Pediatric and Preventive Dentistry
Babu Banarasi Das College of Dental Sciences,
BBDU, Lucknow (U.P.)

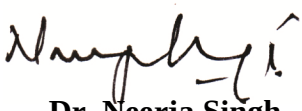
DEPARTMENT OF PEDIATRIC AND PREVENTIVE DENTISTRY

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES, LUCKNOW, UTTAR PRADESH-227105

CERTIFICATE

This is to certify that the dissertation entitled "**A COMPARATIVE EVALUATION OF CUTTING EFFICIENCY OF MANUAL AND ROTARY FILE SYSTEM IN PRIMARY TEETH.**" has been undertaken by the candidate **Dr. NUPUR**, herself in this department. The candidate fulfils all the conditions necessary for the submission of this thesis.

Recommendation of Head of Department



Dr. Neerja Singh

Professor & Head

Department of Pediatric and Preventive Dentistry

Babu Banarasi Das College of Dental Sciences.

BBDU, Lucknow (U.P.)

ENDORSEMENT BY THE HEAD OF INSTITUTION

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES

LUCKNOW, UTTAR PRADESH-227405

CERTIFICATE

This is to certify that the dissertation entitled **"A COMPARATIVE EVALUATION OF CUTTING EFFICIENCY OF MANUAL AND ROTARY FILE SYSTEM IN PRIMARY TEETH."** has been undertaken by the candidate **Dr. NUPUR**, under direct supervision and guidance of **Dr. SOMYA GOVIL**, Reader in the Department of PEDIATRIC AND PREVENTIVE DENTISTRY, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh

Dr. B. Rajkumar

PRINCIPAL

Babu Banarasi Das College of Dental Sciences

BBDU, Lucknow (U.P.)

COPYRIGHT

I hereby declare that the **Babu Banarasi Das University** shall have the right to preserve, use and disseminate this dissertation in print or electronic format for academic / research purpose.

Date: 07/07/21

Place: Lucknow

Nupur

Dr. NUPUR

ACKNOWLEDGEMENTS

This thesis arose in part out of years of research that has been done since I came to Department of Pediatric and Preventive Dentistry, BBDCODS. By that time, I have worked with a great number of people whose contribution in assorted ways to the research and the making of the thesis deserved special mention. It is a pleasure to convey my gratitude to all of them in my humble acknowledgment.

I sincerely thanks to my principal supervisor, ***Dr. Somya Govil ma'am****, for providing me the opportunity to carry out this research work under her esteem guidance. Her encouragement and moral support throughout the research work provided the desired impetus to complete my work successfully. I am very grateful for her patience, motivation, enthusiasm, and immense knowledge that taken together make her a great mentor.*

I would like to express profound gratitude to my co-supervisor, ***Dr. Atul Singh sir,*** *for his encouragement, supervision and constructive criticism throughout this research work. The scientific environment provided in the department is highly appreciated.*

I owe my deepest gratitude to our Hod, ***Dr Neerja Singh ma'am,*** *Prof and Head, Department of Pediatric and Preventive Dentistry, Babu Banarsi Das College of Dental Sciences, Lucknow, for providing me patient samples and his valuable suggestions in clinical work throughout this study.*

I would like to show my gratitude to ***Dr. Monika Rathore ma'am*** *for her all-time moral support and encouragement during my work. The help provided by,* ***Dr.Subash Singh sir****, is highly acknowledged.*

It is a pleasure to thank ***Dr. Naina ma'am, Dr. Sharlin ma'am, Dr. Khyati ma'am*** *and* ***Dr. Mansi ma'am*** *for their support.*

Friends are great asset to one's life. I am extraordinarily fortunate in having friends like ***Anju Varghese and Akhila Sukumar*** *for always being there with me through good and bad times. I am thankful to them for all the emotional support and love. It is a pleasure to express my gratitude wholeheartedly to* ***Dr. Shubham Gupta*** *for unflinching encouragement, support and advice in various ways. I am thankful to* ***Dr. Srishti Beera*** *for her advice and sharing ideas with*

me, which were very fruitful for shaping up my ideas and research. I would also like to thank ***Dr. Sumaiya, Dr. P.Renuka and Dr. Anahita*** *for their help and company.*

I would like to thank my juniors ***Dr. Shama, Dr. Vishakha, Dr. Ritika, Dr. Malika, Dr. Madina, Dr. Raunaq, Dr. Saheli, Dr. Akash, Dr. Bibhav and Dr. Needhi*** *for providing a lively atmosphere in the department. I am thankful to all of them for providing me a stimulating and cordial environment.*

I am as ever, especially indebted to my ***parents*** *for their confidence in me and encouragement to pursue my interests, even when the interests went beyond boundaries of geography. My father taught me to withstand every situation no matter how bad it is. Words fail to express appreciation to my mother without whom this effort would have been worth nothing. She readily listened to my complaints and frustrations, and believed in me. I am very thankful for her love, support and constant patience at tough times.*

I wish to express appreciation to my siblings ***Deepsikha, Deeplata, Abhay and Sapna*** *who have always stood by me during the toughest times and inspired me to tackle every hurdle. Their constant love and support has been a source of happiness and helped me to accomplish my goal.*

Finally I offer my regards and blessings to all those who supported me in any respect during the completion of this research. Last but not least thanks to almighty for providing the strength and energy to complete my work successfully.

Dr. Nupur

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF GRAPHS

LIST OF ANNEXURES

ABSTRACT

Background: Chemo-mechanical canal preparation is one of the most important steps in eliminating germs and debris from the root canal in both permanent and primary teeth, in order to achieve high-level endodontic treatment effectiveness.

Aim: To evaluate and compare cutting efficiency of manual and rotary file systems in primary anterior teeth.

Material and method: A total of forty extracted primary anterior teeth both maxillary and mandibular were collected. They were divided randomly into two groups using Manual instrumentation and Rotary instrumentation. Access cavity preparation was performed in both groups, followed by chemo-mechanical preparation using hand K files and Kedo S rotary files respectively. A CBCT scan was done to assess remaining dentin thickness and canal volume before and after instrumentation. All the canals were obturated with Metapex and again taken for CBCT scan to evaluate quality of obturation.

Results: The canal volume was increased more in hand instrumentation group as compared to the rotary group, while the remaining dentin thickness showed similar results except at the buccal surface of root of cervical third and buccal surface of root of apical third showed significant difference between manual and rotary file system. There was no difference in quality of obturation in either of the groups.

Conclusion: The hand K and rotary Kedo S file systems performed almost identically.

INTRODUCTION

The virtues of science are skepticism and independence of thought.

Walter Gilbert

The removal of infected dentin, dentin debris, vital and/or necrotic pulp tissue, followed by obturation of the root canal system, is the main objective of cleaning and shaping the root canal system.[1]

Many techniques and instruments have been advocated as an effective way to achieve this ultimate goal. Traditionally, the cleaning and shaping have been carried out using time consuming hand files. Manual stainless-steel files provide magnificent tactile control and sharp cutting surfaces. In 1963, Craig and Peyton [2] discovered that stainless steel devices have a lot of potential as endodontic implements. However, the preparation of curved canals is limited according to the shape of file. While calculating working length, K-Flex files have been deployed to deal with severe curvatures. The rigidity of these stainless-steel instruments increases as the size of the instruments increases. As an outcome, various degrees of canal transportation may occur while preparing curved root canals with simple hand instruments, which can lead to ledge formation and zipping perforation. In recent years, a number of innovations have been done to overcome these flaws. [3]

The use of nickel-titanium for file manufacture is one of the many innovations in root canal instrumentation. Nickel-titanium (Ni Ti) files may have an advantage over stainless steel instruments because of their excellent flexibility and resistance to fracture.[3] From 1990s, until now, NiTi instruments have undergone absolute changes in terms of the physical characteristics. So, the paradigm shift has been observed in endodontic treatment from manual stainless steel and nickel-titanium files to rotary instrumentation, hand filing procedures for canal preparation are time intensive and might result in operator-induced errors.

The idea of changing and upgrading these tools is to create a Ni-Ti rotary instrument that penetrate and eliminates infected dentin while remaining fracture resistant even in the most difficult narrow, curved root canals. Another objective of changing and upgrading these instruments is to make the cleaning and shaping

process easier and to reduce the number of instruments used while preserving the shape of the prepared root canals.[4] The most important question with using the rotary instruments including the NiTi files is the possibility of their separation due to cyclic fatigue and the clinicians lack of knowledge and experience. Manufacturers began using heating and cooling methods on NiTi alloys in late 2007 to increase the safety of these devices, particularly in root canals.[5]

Researchers have consistently demonstrated that using a rotary method to prepare root canals in permanent teeth is efficient and successful. However, the primary dentition differs from the permanent dentition in a number of aspects. The differences include the time of development, number of teeth, external morphology and most importantly root canal morphology among others. The size of the pulp relative to the crown is also larger in the primary teeth.

The principles of canal preparation and dentin shaping using Nickel-titanium (Ni-Ti) files have also been applied to primary teeth. Nickel-titanium (Ni-Ti) files were introduced in the field of pediatric endodontics by Barr S et al in 2000[6] which helped in achieving simplicity, speed, accuracy, safety, and stress reduction during root canal preparation, to both the clinician and the patient. But a major concern in applying Nickel-titanium (Ni-Ti) rotary files is the possibility of lateral perforation on the root surface of primary teeth. These lateral perforations may be caused by the rotary files' predesigned larger taper.

The introduction of exclusive pediatric rotary files which have different files for different teeth and also pre-curved files for ribbon like tortuous and uneven canal walls of primary teeth are effectively cleaned with rotary files. Working time and instrumentation time are decreased by utilising exclusive pediatric rotary files. The working of pediatric rotary files helps in a clockwise motion that help to pull out pulpal tissue and dentin out of the canal. The reduced working time and improved root canal preparation with the use of pediatric rotary files is indicated. The steady taper of these files assists with coronal expansion and straight-line access in a controlled manner. It also helps with adequate canal preparation and avoids the need for extensive root surface instrumentation.

According to the manufacturers, the newly introduced Kedo-S rotary file system consists of three Ni-Ti rotary files. All of the files have a varied taper that

corresponds to primary tooth usage. The gradual taper aiding in coronal extension and straight-line access are aided. It also helps to avoid over the instrumentation of the inner wall of the root surface and preserves the native anatomy of the curved canals in primary teeth.[7] This new file system claims to help the dentist in performing the pulpectomy procedure precisely resulting in a uniform and predictable quality of obturation. However, there are only a small number of studies on this rotary file system for canal instrumentation in primary teeth. Hence, this study was undertaken with the aim to evaluate and compare the cutting efficiency of manual and rotary file systems in primary anterior teeth.

Aim & Objectives

AIM

To evaluate and compare cutting efficiency of manual and rotary file systems in primary anterior teeth.

OBJECTIVES

The objectives of this study are:

- To evaluate and compare manual and rotary file systems using cone beam computed tomography for remaining dentin thickness in primary anterior teeth.
- To evaluate and compare manual and rotary file systems using cone beam computed tomography for canal volume in primary anterior teeth.
- To compare quality of obturation in manual and rotary file systems using cone beam computed tomography in primary anterior teeth.

REVIEW OF LITERATURE

Structured review of scientific publications in English literature related to dissertation topic "A comparative evaluation of cutting efficiency of manual and rotary file system in primary teeth: An *In- Vitro* Study"

Until 1960, root canal instruments were produced of carbon steel, which is now replaced by stainless steel alloys. Manufactures have developed new stainless steel alloys characterized by higher flexibility in bending compared with conventional stainless steel instruments to avoid undesirable shaping effects and removing excessive amount of tooth materials from inner aspect of curved canals. Up to now, even flexible stainless steel instruments with noncutting tips have not produced entirely enlargements of severely curved canals. In order to overcome this problem, modifications of stainless steel instruments, have been developed which were highly flexible instruments made of new alloy nickel-titanium (NiTi). NiTi was developed by **W. F. Buehler (1960)**[8] which is non-magnetic, salt resisting and water-proof alloy. This new combination alloy had unique properties of shape memory and super elasticity, which makes engine-driven instruments feasible. With this new technique, there was significant reduction in preparation time and better-cleaned and shaped root canals.

Nagaratna PJ et al (2006)[9] conducted an *in-vitro* investigation to evaluate NiTi rotary and K-files hand instrumentation on root canal preparation of primary & permanent molars for their efficiency in preparation time, instrument failure and shaping the canal. About 20 primary mandibular second molar (I) and 20 permanent mandibular first molar (II) were selected. Each was further divided into 10 for K-files (a) and 10 for NiTi (b) groups, respectively. Results showed that preparation time for primary mandibular second molar for NiTi < primary mandibular second molar for K-files and permanent mandibular first molar for NiTi < permanent mandibular first molar for K-files, which was highly significant. In instrument failure, primary mandibular second molar for K-files (40%), permanent mandibular first molar for K-files (30%) showed more deformation but not fracture and primary mandibular second molar for NiTi (10%), permanent mandibular first molar for NiTi (20%) showed fracture, but not deformation. Profile showed good canal taper and smoothness compared to the K-files. To conclude profile 0.04 taper 29 series, prepared canal

rapidly than conventional K-file with good taper, smoothness though the flow was not satisfactory. Instrument failure with K-files was less. In primary teeth preparation time, instrument failure with profile was less compared to the permanent teeth. To conclude it's encouraging to use the Ni-Ti files in primary teeth. In primary teeth root canal preparation time, instrument failure with Ni-Ti files were less compared to the permanent teeth.

The Ni-Ti alloys files used in rotary systems are composed of 56% Ni and 44% Ti which present a low elasticity modulus, high resilience, corrosion resistance, super elasticity and shape's thermal memory. The flexibility is 2 or 3 times higher than stainless steel files and promote the maintenance of the root canal shape by avoiding canal transportations, an important factor when negotiating the primary molars curved root canals. **Crespo et al (2008)**[10] conducted an *in-vitro* study to compare the efficiency in both, preparation time and root canal shape, when using the Nickel Titanium (Ni-Ti) rotary and K-Files hand instrumentation on root canal preparation of sixty single rooted primary teeth. They concluded that the use of rotary files in primary teeth has several advantages when compared with manual K files: the efficiency in both, preparation time and root canal shape. A decreased working time, that helps maintain patient cooperation by diminishing the potential for tiredness. The shape of the root canal is more conical, favoring a higher quality of the root canal filling, and increasing clinical success.

Romero TO et al (2011)[11] compared the duration of instrumentation, obturation timing and quality of root canal filling between rotary and manual instrumentation techniques. Forty root canal treatments were performed in primary posterior teeth. The results showed that the use of rotary technique diminished the time of instrumentation to 63%. Time of obturation reduced to 68% and it also improved the quality of root canal filling. The study concluded that rotary instrumentation in pulpectomy showed satisfactory results. Even though manual instrumentation is used for that purpose in deciduous teeth, it presents some limitations concerning root canal cleaning, anatomical fidelity and chair time.

Rotary instrumentation using motor-driven nickel-titanium files (Ni-Ti) is an easy technique that requires a smaller number of instruments. Its greater cutting efficacy in dentin reduces the stresses on the files , which present variable tapers to

allow better cleaning, apical control and obturation. Additionally, their similarity with the root canal morphology allows simple and effective preparation, thereby reducing the occurrence of iatrogenic errors. The Ni-Ti rotary instruments are able to maintain the original root canal shape without creating severe irregularities as zipping, steps and perforations, especially in narrow curved canals.

Pinheiro SL et al (2012)[12] done an *in-vitro* study to compare the cleaning ability and instrumentation time between manual and rotary techniques in deciduous molars. 15 extracted deciduous molars included for the study were coronally opened and filled with India ink dye. The results showed that the Protaper system presented shorter instrumentation timing compared to manual instrumentation. Endo-wave system did not present statistically significant difference in instrumentation time compared to other groups.

Farhin et al (2014)[13] conducted an *in-vitro* study on 120 mandibular primary molar to compare instrumentation time and cleaning efficacy of manual instrumentation, rotary systems and reciprocating systems in the preparation of primary molar root canals. The reciprocating and the rotary systems showed better cleaning efficacy when compared to manual instrumentation especially, in coronal and middle one third.

In the bygone decade, several rotary NiTi endodontic file systems have been launched to improve the shaping procedure. However, all these systems recommended the use of a series of files to accomplish the final shape. Recently, the concept of single-file systems has been introduced and is currently being debated for its applicability in contemporary endodontics. **Prabhakar A R et al (2015)[14]** conducted an *in-vitro* study to compare Reciprocating *vs* Rotary Instrumentation. A total of 24 extracted human primary teeth with minimum 7 mm root length were included in the study. Cone beam computed tomographic images were taken before and after the instrumentation for each group. Dentin thickness, centering ability, canal transportation, and instrumentation times were evaluated for each group. A significant difference was found in instrumentation time and canal transportation measures between the two groups. Wave one showed less canal transportation as compared with one shape, and the mean instrumentation time of wave one was significantly less than one shape. Reciprocating single-file systems was found to be faster with much less

procedural errors and can hence be recommended for shaping the root canals of primary teeth.

Zameer M et al (2016)[15] done an *in-vitro* study to evaluate the efficacy of radicular dentin removal, risk of perforation, and shape of the canal on using manual and rotary instruments in primary teeth. Sixty primary teeth selected were divided into three groups; all the teeth were then embedded into resin and sectioned for examination before and after instrumentation. H-files were used for manual technique, and 2% taper and 4% taper I-Race files were used for rotary. No statistical differences were found between 2% and 4% instrumentation with respect to the amount of dentin removed. In few specimens, root perforations were observed in areas coinciding with largest root resorption. In primary teeth without significant root resorption, the use of nickel-titanium-rotary files with 2% and 4% taper up to size 30 revealed to be safe and had prepared the root canals with greater conservation of tooth structure than manual instrumentation. However, 4% taper instrumentation had an additional advantage of providing more funnel-shaped canal desired for ideal compaction of obturating material. The fifth generation of shaping files is the last that has been introduced, with instruments characterized by having the centre of mass and/or rotation offset, with a design, which should minimize the engagement between the file and the dentin.

Colombo M et al (2017)[16] conducted a study to evaluate and analyze periapical radiographs, the technical quality of root canal treatment performed by postgraduate students radiographically on 74 patients. The quality of endodontic treatment was evaluated by examining the length of the filling in relation to the radiographic apex, the density of the obturation according to presence of voids and the taper of root canal filling. It was found that 78% of root canal fillings performed by postgraduate students resulted radiographically adequate.

Govindraju L et al (2017)[17] regulated a study to compare quality of obturation and instrumentation time using hand file and two rotary file system in primary molars. 45 primary mandibular molars were selected. A post obturation radiograph was taken to assess the quality of obturation. Marked reduction in the instrumentation time has been appreciated.

Govindaraju L et al (2017)[18] conducted a study to clinically evaluate quality of obturation and instrumentation time using two modified rotary file systems with manual instrumentation in primary teeth. Forty five mandibular molars were taken and instrumented with k hand file, protaper universal file and K3 rotary file. Digital radiographs were taken to compare but no significant difference were seen with respect to quality of obturation. Statistically significant difference result was seen as rotary file had lesser instrumentation time. There are many in vitro studies done in primary teeth comparing different rotary instrumentation systems with manual instrumentation. As there are no in vivo study done comparing manual files with ProTaper and Mtwo, this randomized, controlled, single-blinded trial was conducted to evaluate the quality of obturation and instrumentation time using K-file, ProTaper, and Mtwo. ProTaper files are triangular in cross-section while the Mtwo files have S-shaped cross section. These files get engaged into the walls of the canals, producing smooth and tapered canal walls.

Reddy J et al (2018)[19] conducted an in vitro study to evaluate the canal cleaning ability of two reciprocating single file systems: Reciproc (VDW, Munich, Germany) and WaveOne gold (Dentsply Maillefer, Ballaigues, Switzerland) using scanning electron microscopy (SEM). Forty freshly extracted human mandibular premolar teeth with single root and canal were selected. The samples were randomly divided into two experimental groups (n = 15 each). The WaveOne Gold group presented a larger amount of debris than the Reciproc Group, however, without a statistically significant difference ($P > 0.05$). A larger amount of debris in the control group was observed, with the statistically significant difference between Reciproc and WaveOne Gold groups ($P < 0.05$). It was concluded that the two reciprocating single-file instrumentation systems presented similar effectiveness for root canal cleaning.

Raidan a (2018)[20] conducted an in vitro study to compare the shaping ability of two rotary nickel-titanium systems manufactured from different NiTi wires. Twenty simulated root canals each with a curvature of 35° in resin blocks were divided into two groups of 10 canals each. In most canal segments, no significant differences were observed between either system in the amount of material removed. Both systems were comparable to each other in regards to their ability to enlarge root canal in the same way without procedural errors.

Manisha et al (2018)[21] conducted an in vivo study to compare post-operative pain after pulpectomy with K-files, Kedo-S files and MTwo files in primary teeth in 4-6 years old children. Despite the tortuous course of primary root canal system, a paradigm shift occurred from conventional hand files to rotary system, which lead to faster, cost-effective, uniform and predictable fillings. 44% of volunteers in K-file group had moderate pain followed by Kedo-S group that is 8% and then MTwo files that is 4%. One of the many advantages being, reduction in post-operative pain with the use of rotary system. Many rotary file systems were introduced, with the recent one, the Kedo-S. So the present study aimed to compare and evaluate the post – operative pain after pulpectomy using K-files, MTwo files and Kedo-S files in deciduous molars. The least post operative pain was found in MTwo group followed by Kedo-S group and K-file group.

Pulpectomy is the choice of treating symptomatic decayed primary teeth and is a challenging and time-consuming procedure in pediatric dentistry. An efficient chemo-mechanical preparation is essential for effective canal disinfection and thereby contributes to the success of the endodontic procedure. Conventionally, hand files are used for cleaning and shaping and are time-consuming. The length of the appointment is strongly associated with the child's behavior. Removal of organic debris is the primary goal of canal preparation in primary teeth. Use of rotary instrumentation for pulpectomy is an emerging practice in pediatric dentistry. The canals of the permanent teeth are prepared rapidly and uniformly with NiTi files resulting in superior obturation. Rotary instrumentation in primary teeth was advocated for its ability to provide conical-shaped canals and reduced the instrumentation time. An in vitro study comparing the canal cleaning capacity of hand files, Mtwo and ProTaper showed no significant differences.[5] Another in vitro study compared the cleaning capacity and instrumentation time of K-files and Mtwo and concluded that there was no significant difference in cleaning capacity, but reduced instrumentation time with the use of Mtwo rotary system was evident.[12] There are no in vivo studies in the literature comparing the manual instrumentation with Mtwo rotary system for pulpectomy in primary teeth.

G jeevanandan et al(2018)[22] conducted an in vivo study to compare and evaluate the instrumentation time and quality of obturation between rotay file(Kedo-S) and manual instrumentation techniques in 4-7 years old children. Mean

instrumentation timing was significantly less and improved quality of obturation with rotary Kedo-S files.

Prashant et al (2019)[23] conducted an *in-vivo* study on 120 patients to compare manual and rotary instrumentation techniques in deciduous teeth. In the study, they found lesser instrumentation time and filling time with rotary system compared to manual endodontic method.

Panchal et al(2019)[24] conducted an in vivo study to compare post-operative pain after root canal instrumentation with hand K- files, H- files and rotary Kedo-S file in 4-6 yrs old children. Rotary files Kedo-S showed significantly less post operative pain as compared to K-file and H-file at 6 and 12 hrs intervals. Among the various rotary file systems, the ProTaper file system is widely used and studied.

Even though until 2016 no files were available exclusively for the preparation of the root canals of primary teeth, the files that were used to prepare the permanent tooth was also used in primary dentition. Invention of Kedo S files, an exclusive rotary endodontic files for primary teeth, was a new venture in the field of pediatric dentistry, more specifically pediatric endodontics. **Seema et al (2020)**[25] conducted an *in-vitro* study on 63 primary molar teeth to compare manual and rotary instrumentation techniques in deciduous teeth. In the study, they found the rotary Kedo S file system performed slightly better in root canal preparations in primary molars. Within the experimental conditions of the present study, the following conclusions were drawn that all the three file systems do not show any statistical significant differences at middle third and apical third but at coronal third Kedo S removed significantly less amount of dentin as compared to the Hand K file on the mesial side and on the distal side all the three file systems performed almost similarly. Taper of the preparations did not show significant differences, even though the rotary files showed good taper in maximum number of root canals.

MATERIALS AND METHODS

The present study was conducted in Department of Paediatric and Preventive Dentistry, Babu Banarasi Das College of Dental Sciences, Lucknow after obtaining clearance from institutional ethical committee of BBDCODS, Lucknow (Annexure 1).

STUDY DESIGN

An *in-vitro* study was performed for comparative evaluation of cutting efficacy in manual and rotary file system for primary teeth. Total 40 extracted teeth were collected and examined.

The teeth were randomly divided into two groups:

Group A: Teeth with manual instrumentation

Group B: Teeth with rotary instrumentation.

SAMPLE SIZE

The sample size was calculated and 40 extracted teeth were included for carrying out the experimental study.

Eligibility Criteria:

Inclusion criteria

1. At least 2/3rd of root remaining
2. At least 2 mm of crown structure present over CEJ

Exclusion Criteria

1. Any evidence of external/internal resorption.

TOOTH STANDARDIZATION

Both maxillary and mandibular extracted primary anterior teeth were included in the study.

Armamentarium:

- Diagnostic Instruments (Root canal explorer 37-123, Mouth Mirror, Tweezer)
- Disposable Syringes (Dispovan) – 24 gauge
- Safe-end diamond-point (ISO No. 220)
- Smooth broach (Dentsply Sirona, USA)
- Barbed broach (Dentsply Sirona, USA)
- Irrigant (3% Sodium Hypochlorite Hyposol, India)
- Hand files Dentsply M-Access K file 21mm
- Rotary files Kedo S file (Reegans Dental Care, India)
- Apex locator (Canal Pro Coltene, India)
- Endomotor (Canal Pro Coltene, India)
- Metapex (Meta Biomed, Korea)

Methodology:

GROUP A

Access cavity preparation:

A sample of 20 extracted teeth was taken. Access opening was performed in extracted teeth. The canals were located with the help of a smooth broach and extirpation of the pulp was done with barbed broach. The roof of the access cavity was removed using safe-end diamond-point (ISO No. 220).

Working length determination:

A no.10 K-file was introduced manually into the root canal using tactile sensation till the apical foramen is reached. On confirming this with the help of an apex locator, a length 1 mm short of the apex was noted as working length for the root canal preparation. The root canal was then prepared up to the estimated canal length.

Chemo-mechanical Preparation:

The pulp chamber was copiously irrigated with a 3% Sodium Hypochlorite (Hyposol, India) solution. Hand K files were then used for preparing the root canals using the step back technique. The last file that was used was the size #40 K file. It was made a point not to go over 3/4 of the canal's estimated length for preventing any endodontic mishaps.

All the samples were taken for specimen analysis using Cone Beam Computed Tomography (CBCT). The parameters measured were:

- Remaining dentin thickness: Dentin removal was assessed at three different levels namely, the coronal third, the middle third and the apical third. At each of these levels, we also assessed the dentin removal on the mesial, distal, buccal, and lingual surfaces of the root.
- Canal volume: CBCT software was used to calculate the canal volume.

Obturation of canals:

After CBCT scan, the 40 canals were again irrigated with 3% Sodium Hypochlorite (Hyposol, India) and dried with the help of paper points so as to start with obturating the canals. Calcium hydroxide iodoform paste (Metapex) was the preferred material for obturation of primary teeth. A standardised mix of metapex without additives or fillers was injected into each canal, as per the manufacturers' recommendation and the technological limitations of obturation procedures. After obturation, a CBCT scan was again conducted for each sample to determine the depth-of-fill. The final obturation was assessed as underfilled, optimally filled and overfilled based on the CBCT scans.

GROUP B

Access cavity preparation:

A sample of 20 extracted teeth was taken. Access opening was performed in extracted teeth. The canals were located with the help of a smooth broach and extirpation of the pulp was done with barbed broach. The roof of the access cavity was removed using safe-end diamond-point (ISO No. 220).

Working length determination:

A no.10 K-file was introduced manually into the root canal using tactile sensation till the apical foramen is reached. On confirming this with the help of an apex locator, a length 1 mm short of the apex was noted as working length for the root canal preparation. The root canal was then prepared up to the estimated canal length.

Chemo-mechanical Preparation:

The pulp chamber was irrigated with 3% Sodium Hypochlorite (Hyposol, India). Root Canals were prepared with the help of Kedo S files till the working length using the Canal Pro Endomotor using the lateral brushing motion. The torque and speed were both adjusted at 2.2–2.4 N cm and 250–300 rpm respectively. It was made a point not to go over 3/4 of the canal's estimated length to prevent any endodontic mishaps.

All the samples were taken for specimen analysis using Cone Beam Computed Tomography (CBCT). The parameters measured were:

- Remaining dentin thickness: Dentin removal was assessed at three different levels namely, the coronal third, the middle third and the apical third. At each of these levels, we also assessed the dentin removal on the mesial, distal, buccal, and lingual surfaces of the root.
- Canal volume: CBCT software was used to calculate the canal volume.

Obturation of canals:

After CBCT scan, the 40 canals were again irrigated with 3% Sodium Hypochlorite (Hyposol, India) and dried with the help of paper points so as to start with obturating the canals. Calcium hydroxide iodoform paste (Metapex) was the preferred material for obturation of primary teeth. A standardised mix of metapex without additives or fillers was injected into each canal, as per the manufacturers' recommendation and the technological limitations of obturation procedures. After obturation, a CBCT scan was again conducted for each sample to determine the depth-of-fill. The final obturation was assessed as underfilled, optimally filled and overfilled based on the CBCT scans.

STATISTICAL METHODS

A total sample size of 40 extracted teeth were included in the study. The sample size per group was calculated by using the following formula-

$$n = \frac{t \times t \times p\,(1-p)}{e^{\wedge}2}$$

$$n = \frac{2*(1.96*1.96)*(13*13}{(8.8*8.8)}$$

$$= 17$$

where, n= sample size, t= confidence level of t statistic at 95%, standard value= 1.96 ,p= difference in groups = 5% ,e= margin of error= 0.05%

The minimum sample size was 17 in each group and it was increased to 20 to guarantee an equitable distribution. Thus, 40 teeth were taken for two groups.

RANDOMIZATION

Allocation of extracted teeth was done randomly to avoid any bias and ensure equal distribution of maxillary and mandibular teeth in both the groups.

Statistical analysis

The continuous remaining dentin thickness and canal volume data were summarised as Mean ± SD (standard deviation). Pre and post groups were compared by paired t-test. Pre to post change (pre-post) in outcome measures of two independent groups were compared by independent Student's t-test. The discrete (categorical) obturation quality data were summarised in number (n) and percentage (%) and compared by chi-square (χ^2) test. A two-tailed (α=2) $p < 0.05$ was considered statistically significant. Analyses were performed on SPSS software (Windows version 22.0).

ARMAMENTARIUM

Diagnostic Instruments & Safe end Diamond Point

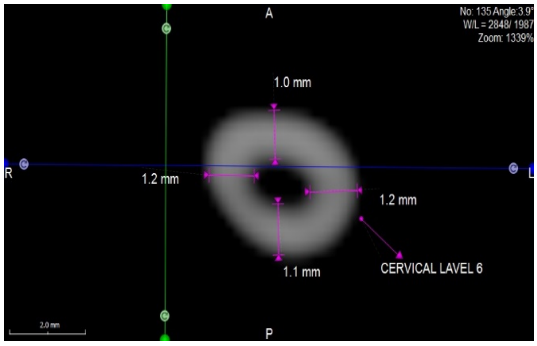
Irrigant

Hand K & Rotary Kedo S Files

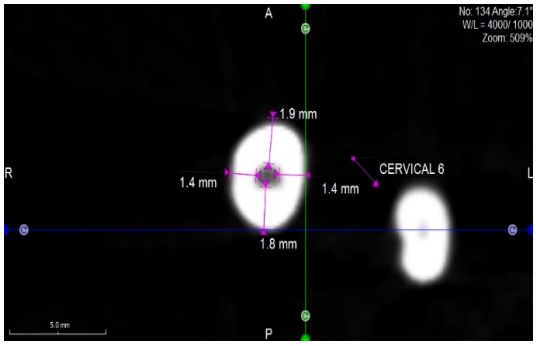
Apex locator & Endomotor

Paper points & Metapex

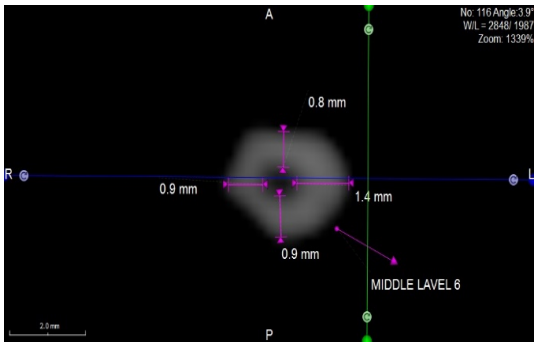
HAND K FILE PRE AND POST INSTRUMENTATION



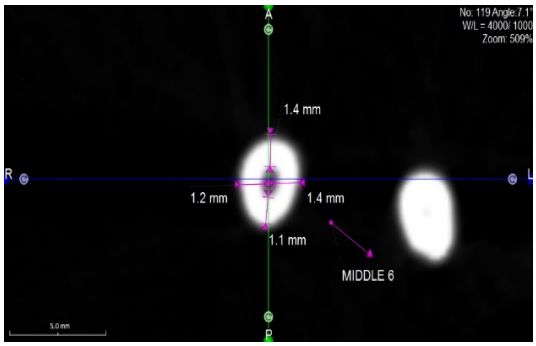
Pre CBCT Scan Cervical Third



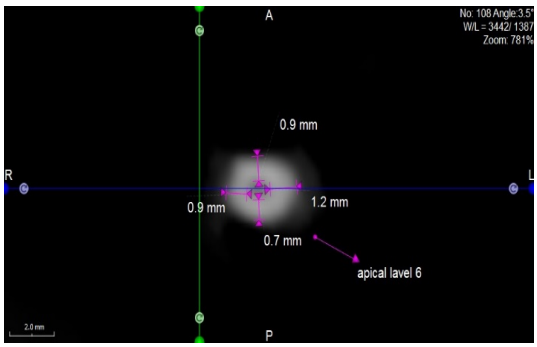
Post CBCT Scan Cervical Third



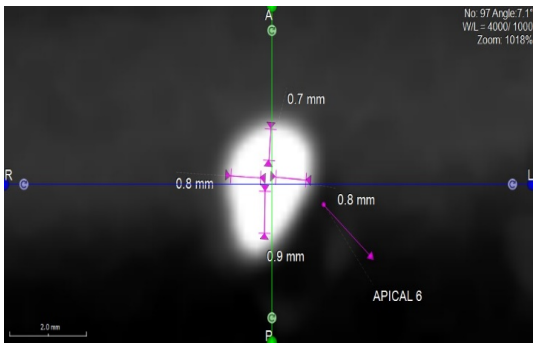
Pre CBCT Scan Middle Third



Post CBCT Scan Middle Third

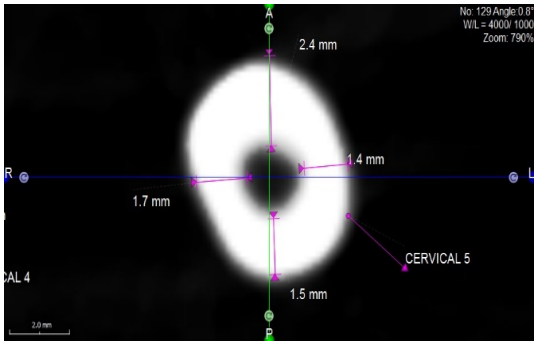


Pre CBCT Scan Apical Third

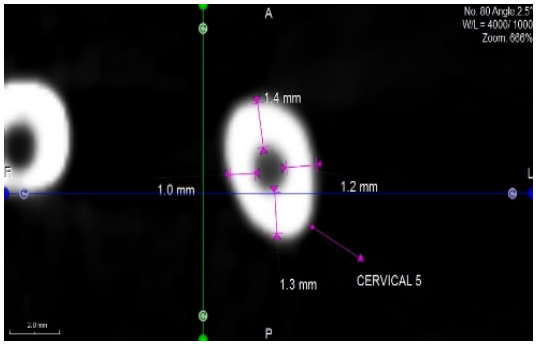


Post CBCT Scan Apical Third

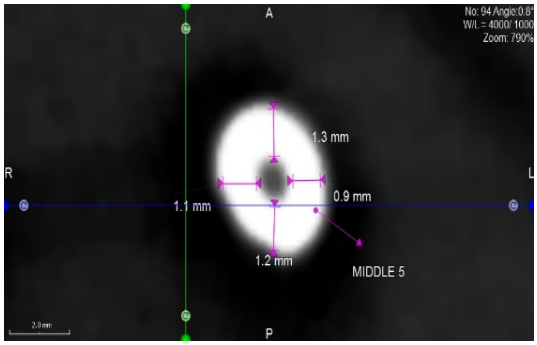
ROTARY KEDO S FILE PRE AND POST INSTRUMENTATION



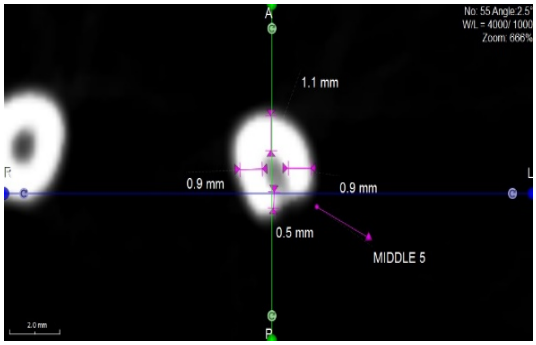
Pre CBCT Scan Cervical Third



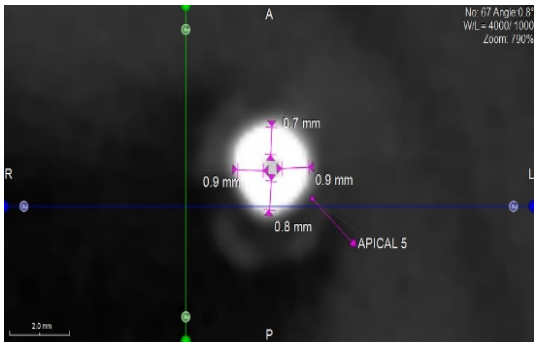
Post CBCT Scan Cervical Third



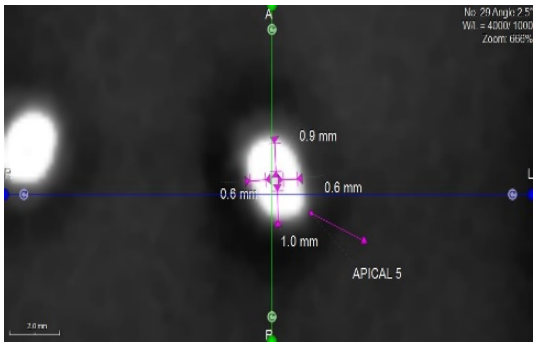
Pre CBCT Scan Middle Third



Post CBCT Scan Middle Third



Pre CBCT Scan Apical Third



Post CBCT Scan Apical Third

RESULTS AND OBSERVATIONS

The present *in-vitro* study deals with the comparative evaluation of cutting efficacy of manual and rotary file systems in primary teeth. Total 40 extracted teeth were collected and randomized equally into two groups and treated with manual instrumentation (*Group 1, n=20*) and rotary instrumentation (*Group 2, n=20*).

The outcome measures of the study were remaining dentin thickness, canal volume and quality of obturation. All the outcome measures were assessed at pre treatment and post treatment. The remaining dentin thickness was measured in millimeter (mm) whereas canal volume was measured in cube millimeter (mm^3) and both were assessed using cone beam computed tomography (CBCT).

The objective of the study was (i) to compare the remaining dentin thickness, (ii) to compare the canal volume, and (iii) to compare the quality of obturation between two groups (Group 1 and Group 2).

Outcome measures

A. Remaining dentin thickness

I. Cervical third

(i) Mesial

The remaining dentin thickness of two groups (Group 1 and Group 2) at the mesial side of the cervical third is summarised in Table 1 and also depicted in Graph 1-2. In both groups, the mean dentin thickness at the mesial side of the cervical third decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.

At mesial, the mean (± SD) dentin thickness of Group 1 at pre was 1.32 ± 0.31 mm and post it was 1.15 ± 0.24 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t-test showed similar ($p > 0.05$) dentin thickness between the two periods (1.32 ± 0.31 vs. 1.15 ± 0.24, diff=0.17 ± 0.46, t=1.66, $p = 0.114$) i.e. did not change (or decrease) significantly (Table 1 and Graph 1).

In contrast, in Group 2, it was 1.17 ± 0.22 mm at pre and 0.95 ± 0.26 mm at post and it decreased significantly ($p < 0.001$) at post as compared to pre (1.17 ± 0.22 vs. 0.95 ± 0.26, diff=0.22 ± 0.10, t=10.34, $p < 0.001$) (Table 1 and Graph 1)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t-test showed similar ($p > 0.05$) remaining dentin thickness between the two groups (0.17 ± 0.46 vs. 0.22 ± 0.10, diff=0.05, t=0.48, p = 0.636) though it remained 22.7% higher in Group 2 as compared to Group 1 (Table 1 and Graph 2).

(ii) Distal

The remaining dentin thickness of two groups at the distal side of the cervical third is summarised in Table 1 and also depicted in Graph 3-4. In both groups, the mean dentin thickness at the distal side of the cervical third also decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.

At the distal level, the mean dentin thickness of Group 1 at pre was 1.33 ± 0.35 mm and post it was 1.24 ± 0.22 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t-test showed similar ($p > 0.05$) dentin thickness between the two periods (1.33 ± 0.35 vs. 1.24 ± 0.22, diff=0.09 ± 0.48, t=0.79, p = 0.442) i.e. did not change (or decrease) significantly (Table 1 and Graph 3).

In contrast, in Group 2, it was 0.80 ± 0.12 mm at pre and 0.64 ± 0.11 mm at post and it decreased significantly ($p < 0.001$) at post as compared to pre (0.80 ± 0.12 vs. 0.64 ± 0.11, diff=0.16 ± 0.07, t=10.10, $p < 0.001$) (Table 1 and Graph 3)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups (0.09 ± 0.48 vs. 0.16 ± 0.07, diff=0.07, t=0.64, p = 0.526) though it remained 45.2% higher in Group 2 as compared to Group 1 (Table 1 and Graph 4).

(iii) Buccal

The remaining dentin thickness of two groups at the buccal side of the cervical third is summarised in Table 1 and also depicted in Graph 5-6. In both groups, the

mean dentin thickness at the buccal side of the cervical third also decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.

At buccal, the mean dentin thickness of Group 1 at pre was 1.35 ± 0.23 mm and post it was 1.33 ± 0.25 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t-test showed similar ($p > 0.05$) dentin thickness between the two periods (1.35 ± 0.23 vs. 1.33 ± 0.25, diff=0.02 ± 0.36, t=0.19, $p = 0.855$) i.e. did not change (or decrease) significantly (Table 1 and Graph 5).

In contrast, in Group 2, it was 1.23 ± 0.22 mm at pre and 1.03 ± 0.21 mm at post and it decreased significantly ($p < 0.001$) at post as compared to pre (1.23 ± 0.22 vs. 1.03 ± 0.21, diff=0.20 ± 0.12, t=7.65, $p < 0.001$) (Table 1 and Graph 5)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t-test showed significantly ($p < 0.05$) different and higher (92.5%) remaining dentin thickness in Group 2 as compared to Group 1 (0.02 ± 0.36 vs. 0.20 ± 0.12, diff=0.18, t=2.18, $p = 0.036$) (Table 1 and Graph 6).

(iv) Lingual

The remaining dentin thickness of two groups at the lingual side of the cervical third is summarised in Table 1 and also depicted in Graph 7-8. In both groups, the mean dentin thickness at the lingual side of the cervical third also decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.

At lingual, the mean dentin thickness of Group 1 at pre was 1.29 ± 0.35 mm and post it was 1.19 ± 0.31 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t-test showed similar ($p > 0.05$) dentin thickness between the two periods (1.29 ± 0.35 vs. 1.19 ± 0.31, diff=0.10 ± 0.53, t=0.80, $p = 0.433$) i.e. did not change (or decrease) significantly (Table 1 and Graph 7).

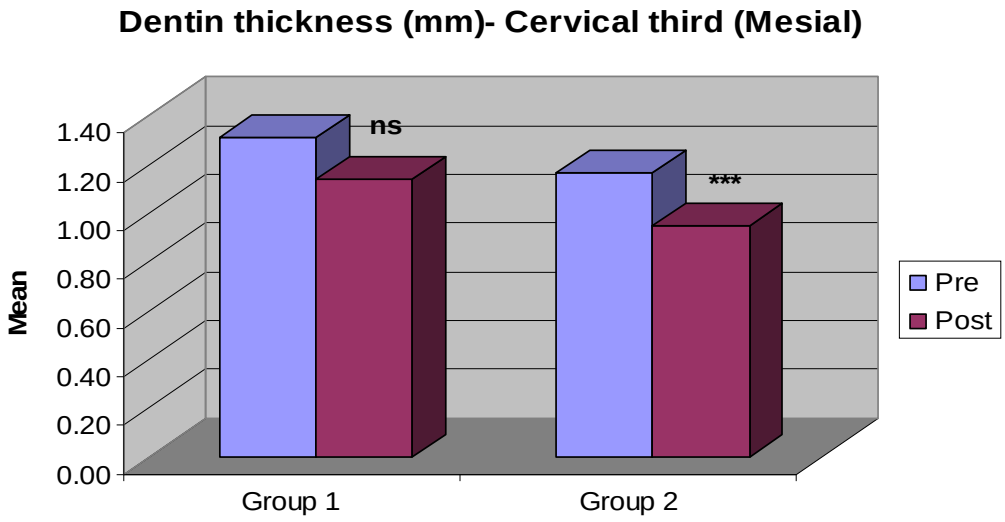
In contrast, in Group 2, it was 1.40 ± 0.24 mm at pre and 1.17 ± 0.22 mm at post and it decreased significantly ($p < 0.001$) at post as compared to pre (1.40 ± 0.24 vs. 1.17 ± 0.22, diff=0.24 ± 0.12, t=8.57, $p < 0.001$) (Table 1 and Graph 7)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t-test showed similar ($p > 0.05$) remaining dentin thickness between the two groups (0.10 ± 0.53 vs. 0.24 ± 0.12, diff=0.14, t=1.15, $p = 0.258$) though it remained 59.6% higher in Group 2 as compared to Group 1 (Table 1 and Graph 8).

Table 1: Remaining dentin thickness (mm) of two groups at mesial, distal, buccal and lingual sides of cervical third

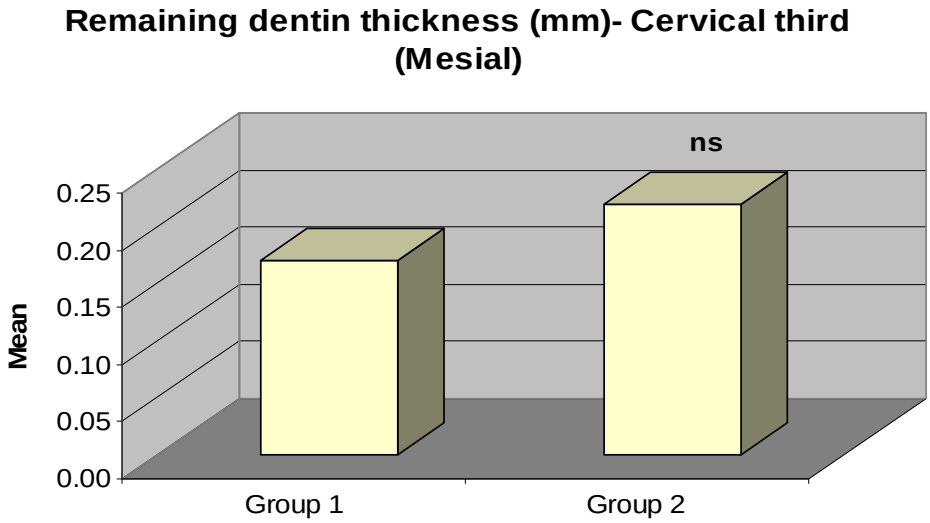
Sides	Group 1 (n=20)					Group 2 (n=20)					Comparison of change (Group 1 vs. Group 2)				
	Pre	Post	Change (Pre-ost)	t value	*p* value	Pre	Post	Change (Pre-ost)	t value	*p* value	Group 1	Group 2	Diff. (%)	t value	*p* value
Mesial	1.32 ± 0.31	1.15 ± 0.24	0.17 ± 0.46	1.66	0.114	1.17 ± 0.22	0.95 ± 0.26	0.22 ± 0.10	10.34	<0.001	0.17 ± 0.46	0.22 ± 0.10	0.05 (22.7)	0.48	0.636
Distal	1.33 ± 0.35	1.24 ± 0.22	0.09 ± 0.48	0.79	0.442	0.80 ± 0.12	0.64 ± 0.11	0.16 ± 0.07	10.10	<0.001	0.09 ± 0.48	0.16 ± 0.07	0.07 (45.2)	0.64	0.526
Buccal	1.35 ± 0.23	1.33 ± 0.25	0.02 ± 0.36	0.19	0.855	1.23 ± 0.22	1.03 ± 0.21	0.20 ± 0.12	7.65	<0.001	0.02 ± 0.36	0.20 ± 0.12	0.18 (92.5)	2.18	0.036
Lingual	1.29 ± 0.35	1.19 ± 0.31	0.10 ± 0.53	0.80	0.433	1.40 ± 0.24	1.17 ± 0.22	0.24 ± 0.12	8.57	<0.001	0.10 ± 0.53	0.24 ± 0.12	0.14 (59.6)	1.15	0.258

The remaining dentin thickness of two groups at mesial, distal, buccal and lingual sides of cervical third is summarised in Mean ± SD. The pre and post data of each group was compared by paired t test whereas pre to post change (pre-post) between two groups were compared by Student's t test.



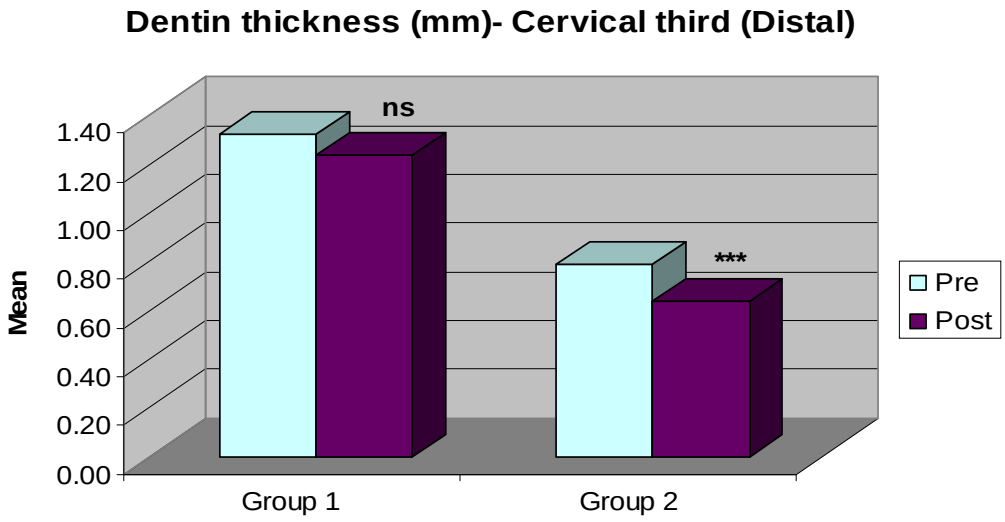
$^{ns}p > 0.05$ or $^{***}p < 0.001$- as compared to Pre.

Graph 1. For each group, bar graphs showing comparison of difference in pre and post mean dentin thickness at mesial side of cervical third. In both groups, the mean dentin thickness at the mesial side of the cervical third decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.



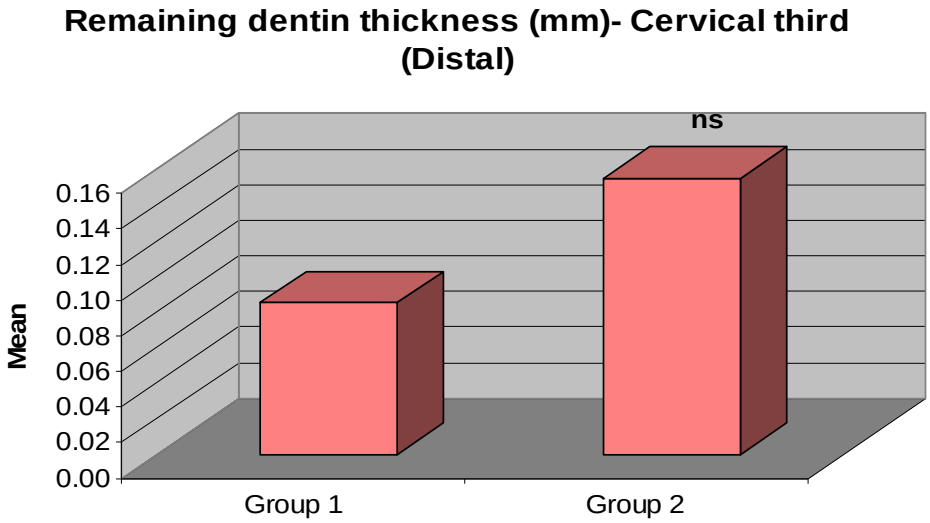
$^{ns}p > 0.05$- as compared to Group 1

Graph 2. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at mesial side of cervical third. Student's t-test showed remaining dentin thickness between the two groups it remained 22.7% higher in Group 2 as compared to Group 1



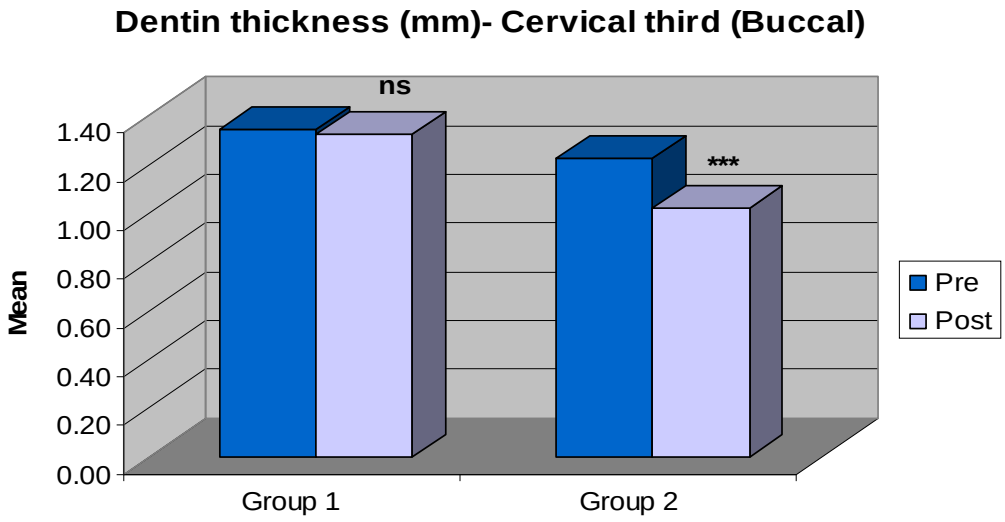
$^{ns}p > 0.05$ or $^{***}p < 0.001$- as compared to Pre

Graph 3. For each group, bar graphs showing comparison of difference in pre and post mean dentin thickness at distal side of cervical third. In both groups, the mean dentin thickness at the distal side of the cervical third also decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.



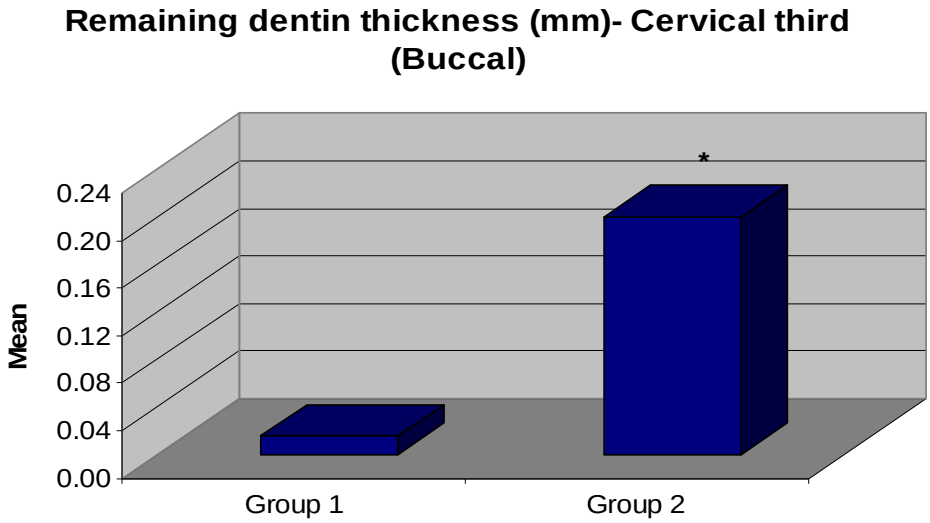
$^{ns}p > 0.05$- as compared to Group 1.

Graph 4. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at distal side of cervical third. Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups though it remained 45.2% higher in Group 2 as compared to Group 1



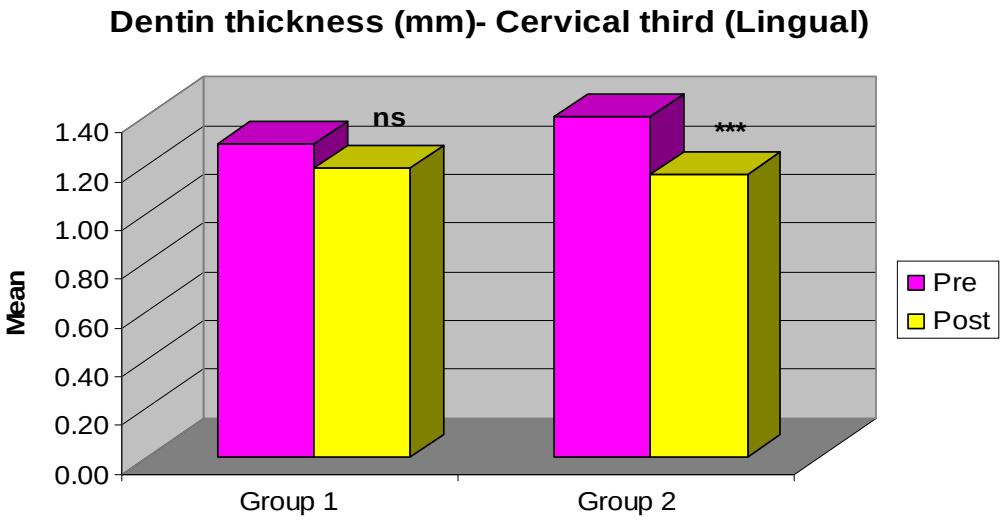
$^{ns}p > 0.05$ or $^{***}p < 0.001$- as compared to Pre

Graph 5. For each group, bar graphs showing comparison of difference in pre and post mean dentin thickness at buccal side of cervical third. In both groups, the mean dentin thickness at the buccal side of the cervical third also decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.



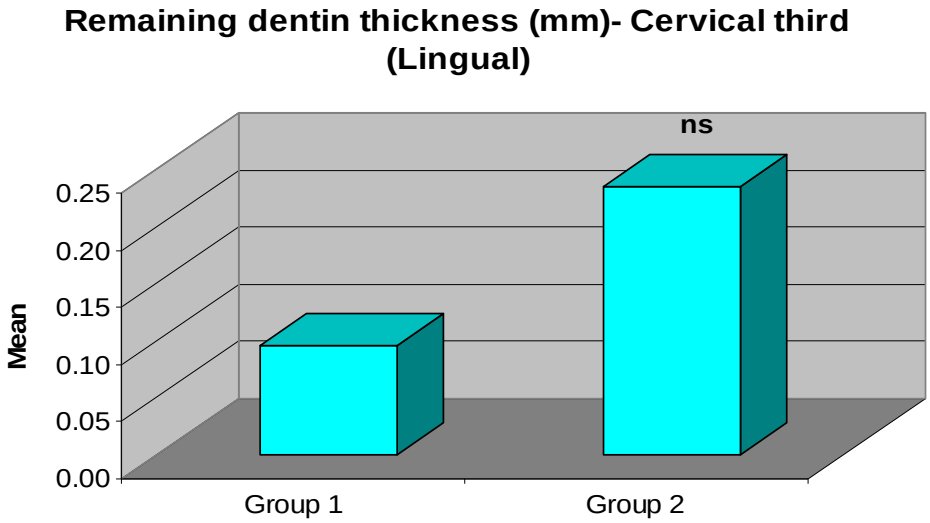
$^{*}p < 0.05$- as compared to Group 1

Graph 6. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at buccal side of cervical third. Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups though it remained 92.5% higher in Group 2 as compared to Group 1.



$^{ns}p > 0.05$ or $^{***}p < 0.001$- as compared to Pre

Graph 7. For each group, bar graphs showing comparison of difference in pre and post mean dentin thickness at lingual side of cervical third. In both groups, the mean dentin thickness at the lingual side of the cervical third also decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.



$^{ns}p > 0.05$- as compared to Group 1

Graph 8. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at lingual side of cervical third. Student's t-test showed similar ($p > 0.05$) remaining dentin thickness between the two groupsthough it remained 59.6% higher in Group 2 as compared to Group 1

II. Middle third

(i) Mesial

The remaining dentin thickness of two groups at mesial side of middle third is summarised in Table 2 and also depicted in Graph 9-10. In both groups, the mean dentin thickness at mesial side of middle third decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident higher in Group 1 as compared to Group 2.

At mesial, the mean dentin thickness of Group 1 at pre was 1.03 ± 0.21 mm and post it was 0.78 ± 0.20 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t test showed significant ($p < 0.01$) decrease in dentin thickness at post as compared to pre (1.03 ± 0.21 vs. 0.78 ± 0.20, diff=0.25 ± 0.29, t=3.74, $p = 0.001$) (Table 2 and Graph 9).

Similarly, in Group 2, it was 1.06 ± 0.21 mm at pre and 0.86 ± 0.18 mm at post and it also decreased significantly ($p < 0.001$) at post as compared to pre (1.06 ± 0.21 vs. 0.86 ± 0.18, diff=0.20 ± 0.07, t=12.33, $p < 0.001$) (Table 2 and Graph 9)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups (0.25 ± 0.29 vs. 0.20 ± 0.07, diff=0.05, t=0.67, $p = 0.509$) though it remained 18.4% higher in Group 1 as compared to Group 2 (Table 2 and Graph 10).

(ii) Distal

The remaining dentin thickness of two groups at distal side of middle third is summarised in Table 2 and also depicted in Graph 11-12. In both groups, the mean dentin thickness at distal side of middle third also decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident almost similar between the two groups.

At distal, the mean dentin thickness of Group 1 at pre was 1.11 ± 0.22 mm and post it was 0.94 ± 0.22 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t test showed significant ($p < 0.05$) decrease in dentin thickness at

post as compared to pre (1.11 ± 0.22 vs. 0.94 ± 0.22, diff=0.17 ± 0.33, t=2.32, p = 0.032) (Table 2 and Graph 11).

Similarly, in Group 2, it was 1.15 ± 0.20 mm at pre and 0.98 ± 0.18 mm at post and it also decreased significantly ($p < 0.001$) at post as compared to pre (1.15 ± 0.20 vs. 0.98 ± 0.18, diff=0.17 ± 0.07, t=10.38, $p < 0.001$) (Table 2 and Graph 11)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups (0.17 ± 0.33 vs. 0.17 ± 0.07, diff=0.00, t=0.00, p = 1.000) (Table 2 and Graph 12).

(iii) Buccal

The remaining dentin thickness of two groups at buccal side of middle third is summarised in Table 2 and also depicted in Graph 13-14. In both groups, the mean dentin thickness at buccal side of middle third also decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident slightly higher in Group 2 as compared to Group 1.

At buccal, the mean dentin thickness of Group 1 at pre was 1.10 ± 0.28 mm and post it was 0.94 ± 0.33 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t test showed similar ($p > 0.05$) dentin thickness between the two periods (1.10 ± 0.28 vs. 0.94 ± 0.33, diff=0.17 ± 0.44, t=1.69, p = 0.108) i.e. did not change (or decrease) significantly (Table 2 and Graph 13).

In contrast, in Group 2, it was 1.11 ± 0.18 mm at pre and 0.93 ± 0.19 mm at post and it decreased significantly ($p < 0.001$) at post as compared to pre (1.11 ± 0.18 vs. 10.93 ± 0.19, diff=0.18 ± 0.07, t=11.57, $p < 0.001$) (Table 2 and Graph 13)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups (0.17 ± 0.44 vs. 0.18 ± 0.07, diff=0.02, t=0.15, p = 0.880) though it remained 8.3% higher in Group 2 as compared to Group 1 (Table 2 and Graph 14).

(iv) Lingual

The remaining dentin thickness of two groups at lingual side of middle third is summarised in Table 2 and also depicted in Graph 15-16. In both groups, the mean dentin thickness at lingual side of middle third also decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident higher in Group 2 as compared to Group 1.

At lingual, the mean dentin thickness of Group 1 at pre was 1.00 ± 0.23 mm and post it was 0.89 ± 0.30 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t test showed similar ($p > 0.05$) dentin thickness between the two periods (1.00 ± 0.23 vs. 0.89 ± 0.30, diff=0.11 ± 0.30, t=1.58, $p = 0.130$) i.e. did not change (or decrease) significantly (Table 2 and Graph 15).

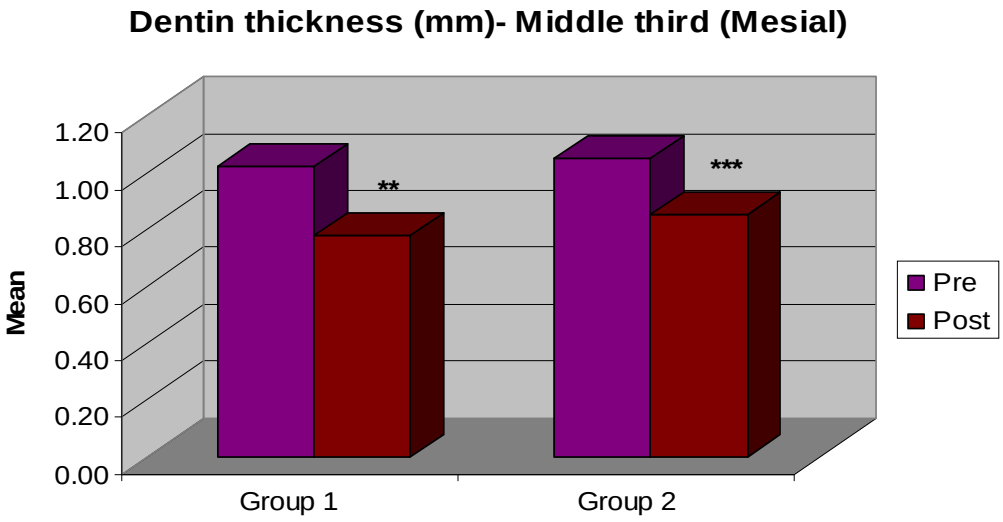
In contrast, in Group 2, it was 0.96 ± 0.14 mm at pre and 0.78 ± 0.12 mm at post and it decreased significantly ($p < 0.001$) at post as compared to pre (0.96 ± 0.14 vs. 0.78 ± 0.12, diff=0.18 ± 0.06, t=14.23, $p < 0.001$) (Table 2 and Graph 15)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups (0.11 ± 0.30 vs. 0.18 ± 0.06, diff=0.07, t=1.04, $p = 0.306$) though it remained 40.0% higher in Group 2 as compared to Group 1 (Table 2 and Graph 16).

Table 2: Remaining dentin thickness (mm) of two groups at mesial, distal, buccal and lingual sides of middle third

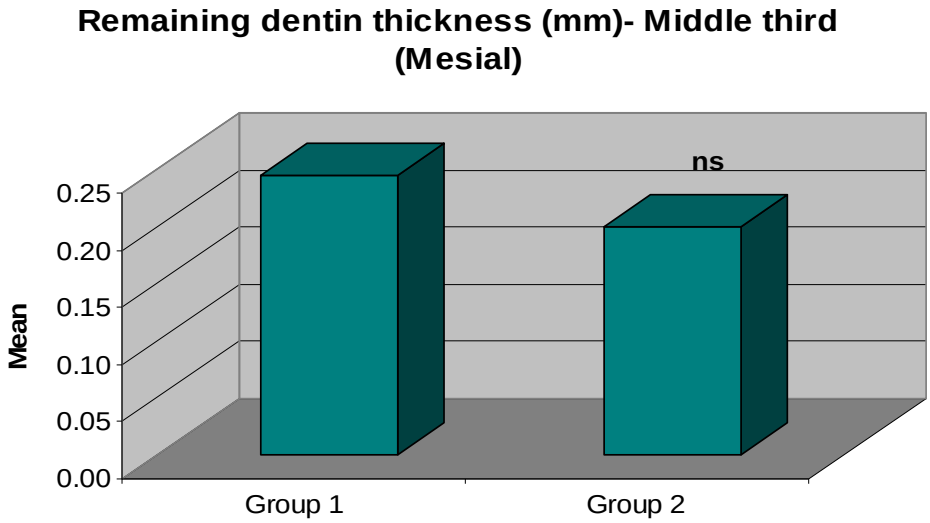
Sides	Group 1 (n=20)					Group 2 (n=20)					Comparison of change (Group 1 vs. Group 2)				
	Pre	Post	Change (Pre-ost)	t value	*p* value	Pre	Post	Change (Pre-ost)	t value	*p* value	Group 1	Group 2	Diff. (%)	t value	*p* value
Mesial	1.03 ± 0.21	0.78 ± 0.20	0.25 ± 0.29	3.74	0.001	1.06 ± 0.21	0.86 ± 0.18	0.20 ± 0.07	12.33	<0.001	0.25 ± 0.29	0.20 ± 0.07	0.05 (18.4)	0.67	0.509
Distal	1.11 ± 0.22	0.94 ± 0.22	0.17 ± 0.33	2.32	0.032	1.15 ± 0.20	0.98 ± 0.18	0.17 ± 0.07	10.38	<0.001	0.17 ± 0.33	0.17 ± 0.07	0.00 (0.0)	0.00	1.000
Buccal	1.10 ± 0.28	0.94 ± 0.33	0.17 ± 0.44	1.69	0.108	1.11 ± 0.18	0.93 ± 0.19	0.18 ± 0.07	11.57	<0.001	0.17 ± 0.44	0.18 ± 0.07	0.01 (8.3)	0.15	0.880
Lingual	1.00 ± 0.23	0.89 ± 0.30	0.11 ± 0.30	1.58	0.130	0.96 ± 0.14	0.78 ± 0.12	0.18 ± 0.06	14.23	<0.001	0.11 ± 0.30	0.18 ± 0.06	0.07 (40.0)	1.04	0.306

The remaining dentin thickness of two groups at mesial, distal, buccal and lingual sides of middle third is summarised in Mean ± SD. The pre and post data of each group was compared by paired t test whereas pre to post change (pre-post) between two groups were compared by Student's t test.



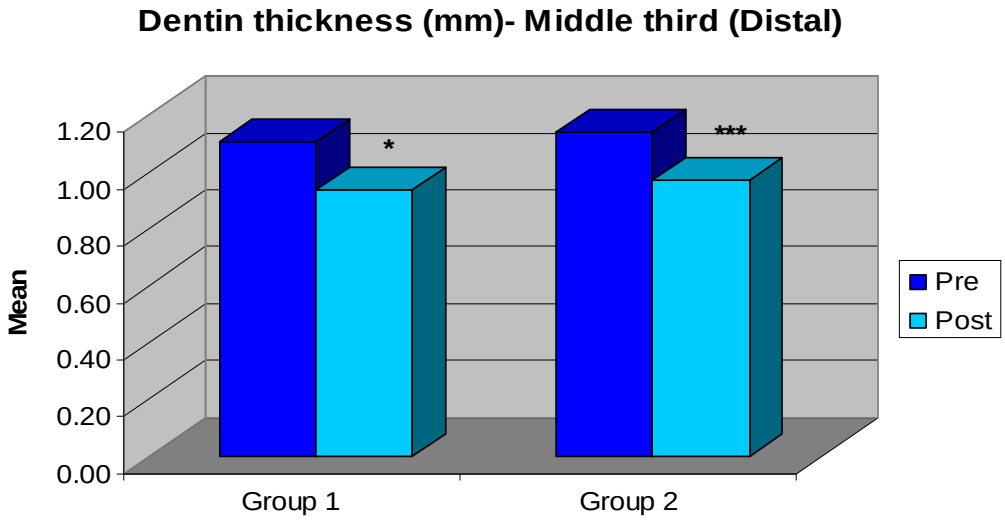
$^{**}p < 0.01$ or $^{***}p < 0.001$- as compared to Pre

Graph 9. For each group, bar graphs showing comparison of difference in pre and ost mean dentin thickness at mesial side of middle third. In both groups, the mean dentin thickness at the mesial side of the middle third also decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.



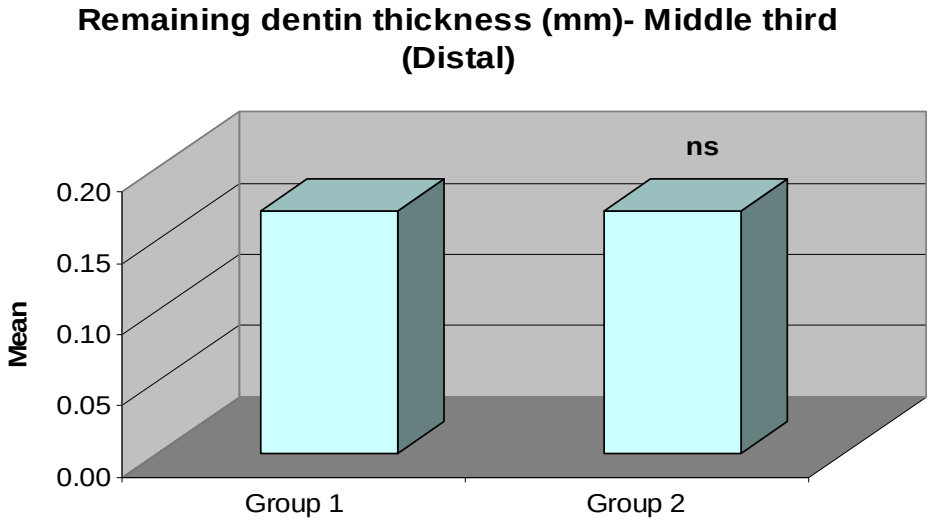
$^{ns}p > 0.05$- as compared to Group 1

Graph 10. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at mesial side of middle third. Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups though it remained 18.4% higher in Group 1 as compared to Group 2



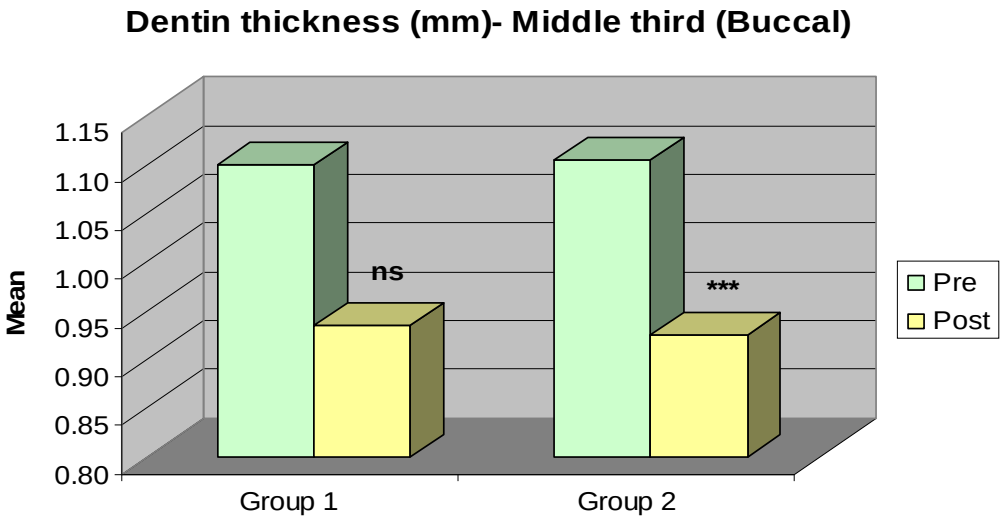
$^{*}p < 0.05$ or $^{***}p < 0.001$- as compared to Pre

Graph 11. For each group, bar graphs showing comparison of difference in pre and post mean dentin thickness at distal side of middle third. In both groups, the mean dentin thickness at the distal side of the middle third also decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.



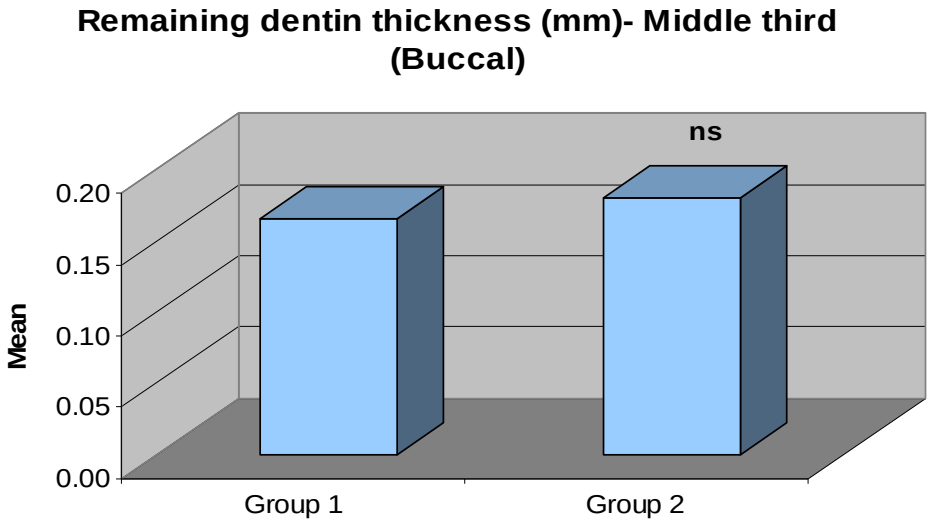
$^{ns}p > 0.05$- as compared to Group 1

Graph 12. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at distal side of middle third. Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups.



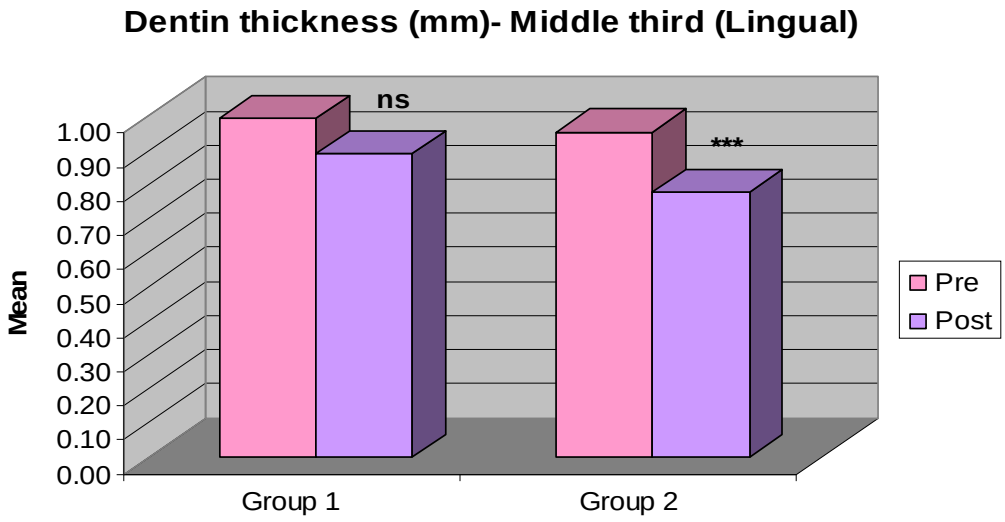
$^{ns}p > 0.05$ or $^{***}p < 0.001$- as compared to Pre

Graph 13. For each group, bar graphs showing comparison of difference in pre and post mean dentin thickness at buccal side of middle third. In both groups, the mean dentin thickness at the buccal side of the middle third also decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.



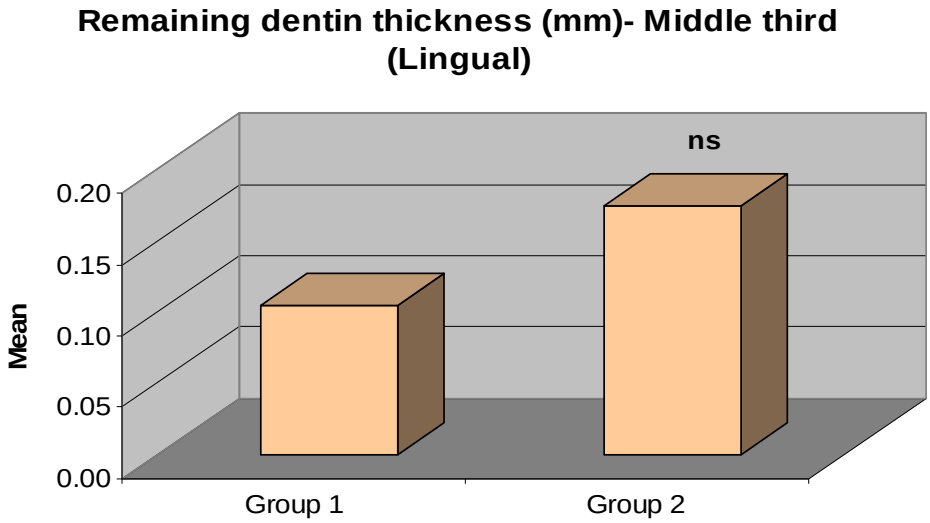
$^{ns}p > 0.05$- as compared to Group 1

Graph 14. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at buccal side of middle third. Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups though it remained 8.3% higher in Group 2 as compared to Group 1



$^{ns}p > 0.05$ or $^{***}p < 0.001$- as compared to Pre

Graph 15. For each group, bar graphs showing comparison of difference in pre and post mean dentin thickness at lingual side of middle third. In both groups, the mean dentin thickness at the lingual side of the middle third also decreased (or changed) comparatively at the post as compared to pre and the decrease (restoration) was evidently higher in Group 2 as compared to Group 1.



$^{ns}p > 0.05$- as compared to Group 1

Graph 16. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at lingual side of middle third. Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups though it remained 40.0% higher in Group 2 as compared to Group 1

III. Apical third

(i) Mesial

The remaining dentin thickness of two groups at mesial side of apical third is summarised in Table 3 and also depicted in Graph 17-18. In both groups, the mean dentin thickness at mesial side of apical third decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident slightly higher in Group 2 as compared to Group 1.

At mesial, the mean dentin thickness of Group 1 at pre was 0.67 ± 0.19 mm and post it was 0.56 ± 0.18 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t test showed significant ($p < 0.05$) decrease in dentin thickness at post as compared to pre (0.67 ± 0.19 vs. 0.56 ± 0.18, diff=0.11 ± 0.18, t=2.77, $p = 0.012$) (Table 3 and Graph 17).

Similarly, in Group 2, it was 0.79 ± 0.15 mm at pre and 0.65 ± 0.11 mm at post and it also decreased significantly ($p < 0.001$) at post as compared to pre (0.79 ± 0.15 vs. 0.65 ± 0.11, diff=0.14 ± 0.06, t=10.28, $p < 0.001$) (Table 3 and Graph 17)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups (0.11 ± 0.18 vs. 0.14 ± 0.06, diff=0.03, t=0.60, $p = 0.553$) though it remained 18.5% higher in Group 2 as compared to Group 1 (Table 3 and Graph 18).

(ii) Distal

The remaining dentin thickness of two groups at distal side of apical third is summarised in Table 3 and also depicted in Graph 19-20. In both groups, the mean dentin thickness at distal side of apical third also decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident slightly higher in Group 2 as compared to Group 1.

At distal, the mean dentin thickness of Group 1 at pre was 0.72 ± 0.28 mm and post it was 0.55 ± 0.21 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t test showed significant ($p < 0.01$) decrease in dentin thickness at

post as compared to pre (0.72 ± 0.28 vs. 0.55 ± 0.21, diff=0.17 ± 0.23, t=3.21, p = 0.005) (Table 3 and Graph 19).

Similarly, in Group 2, it was 0.65 ± 0.09 mm at pre and 0.40 ± 0.09 mm at post and it also decreased significantly ($p < 0.001$) at post as compared to pre (0.65 ± 0.09 vs. 0.40 ± 0.09, diff=0.25 ± 0.09, t=11.82, $p < 0.001$) (Table 3 and Graph 19)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups (0.17 ± 0.23 vs. 0.25 ± 0.09, diff=0.08, t=1.53, p = 0.135) though it remained 34.0% higher in Group 2 as compared to Group 1 (Table 3 and Graph 20).

(iii) Buccal

The remaining dentin thickness of two groups at buccal side of apical third is summarised in Table 3 and also depicted in Graph 21-22. In both groups, the mean dentin thickness at buccal side of apical third also decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident comparatively higher in Group 2 as compared to Group 1.

At buccal, the mean dentin thickness of Group 1 at pre was 0.68 ± 0.22 mm and post it was 0.59 ± 0.26 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t test showed similar ($p > 0.05$) dentin thickness between the two periods (0.68 ± 0.22 vs. 0.59 ± 0.26, diff=0.10 ± 0.22, t=1.92, p = 0.070) i.e. did not change (or decrease) significantly (Table 3 and Graph 21).

In contrast, in Group 2, it was 0.86 ± 0.11 mm at pre and 0.62 ± 0.10 mm at post and it decreased significantly ($p < 0.001$) at post as compared to pre (0.86 ± 0.11 vs. 0.62 ± 0.10, diff=0.24 ± 0.09, t=12.01, $p < 0.001$) (Table 3 and Graph 21)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t test showed significantly ($p < 0.05$) different and higher (59.6%) remaining dentin thickness in Group 2 as compared to Group 1 (0.10 ± 0.22 vs. 0.24 ± 0.09, diff=0.14, t=2.63, p = 0.012) (Table 3 and Graph 22).

(iv) Lingual

The remaining dentin thickness of two groups at lingual side of apical third is summarised in Table 3 and also depicted in Graph 23-24. In both groups, the mean dentin thickness at lingual side of apical third also decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident slightly higher in Group 2 as compared to Group 1.

At lingual, the mean dentin thickness of Group 1 at pre was 0.68 ± 0.24 mm and post it was 0.54 ± 0.20 mm. Comparing the pre and post mean dentin thickness of Group 1, paired t test showed significant ($p < 0.05$) decrease in dentin thickness at post as compared to pre (0.68 ± 0.24 vs. 0.54 ± 0.20, diff=0.14 ± 0.23, t=2.77, $p = 0.012$) (Table 3 and Graph 23).

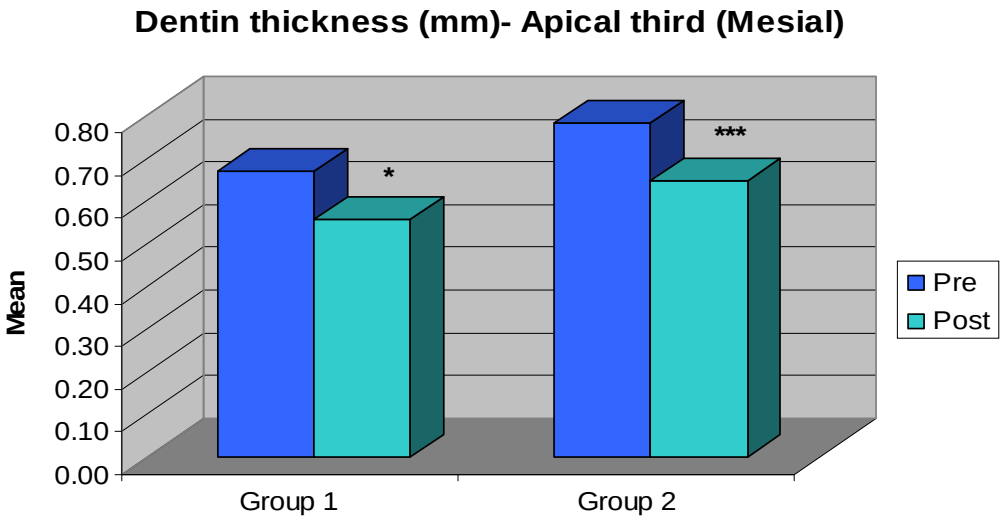
Similarly, in Group 2, it was 0.84 ± 0.13 mm at pre and 0.66 ± 0.12 mm at post and it also decreased significantly ($p < 0.001$) at post as compared to pre (0.84 ± 0.13 vs. 0.66 ± 0.12, diff=0.18 ± 0.12, t=6.99, $p < 0.001$) (Table 3 and Graph 23)

Further, comparing the pre to post mean change in dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups (0.14 ± 0.23 vs. 0.18 ± 0.12, diff=0.04, t=0.71, $p = 0.485$) though it remained 22.2% higher in Group 2 as compared to Group 1 (Table 3 and Graph 24).

Table 3: Remaining dentin thickness (mm) of two groups at mesial, distal, buccal and lingual sides of apical third

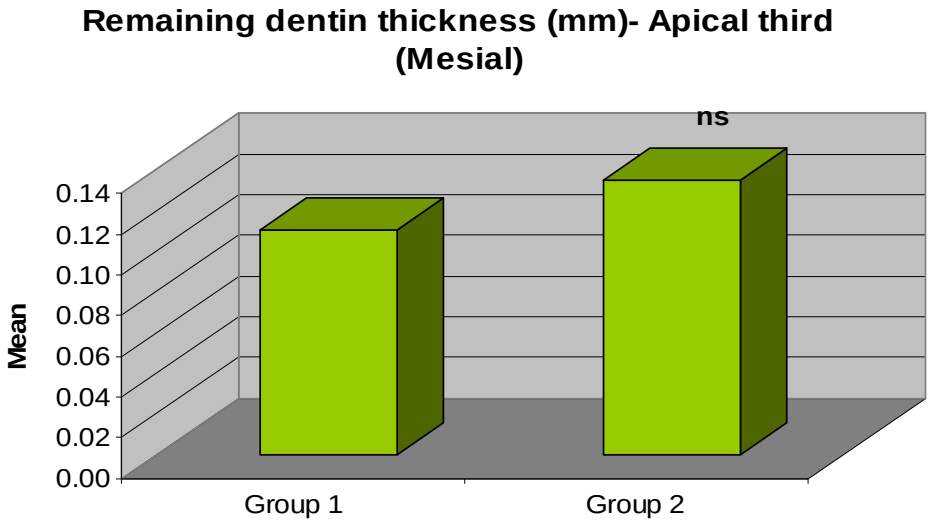
Sides	Group 1 (n=20)					Group 2 (n=20)					Comparison of change (Group 1 vs. Group 2)				
	Pre	Post	Change (Pre-ost)	t value	*p* value	Pre	Post	Change (Pre-ost)	t value	*p* value	Group 1	Group 2	Diff. (%)	t value	*p* value
Mesial	0.67 ± 0.19	0.56 ± 0.18	0.11 ± 0.18	2.77	0.012	0.79 ± 0.15	0.65 ± 0.11	0.14 ± 0.06	10.28	<0.001	0.11 ± 0.18	0.14 ± 0.06	0.03 (18.5)	0.60	0.553
Distal	0.72 ± 0.28	0.55 ± 0.21	0.17 ± 0.23	3.21	0.005	0.65 ± 0.09	0.40 ± 0.09	0.25 ± 0.09	11.82	<0.001	0.17 ± 0.23	0.25 ± 0.09	0.08 (34.0)	1.53	0.135
Buccal	0.68 ± 0.22	0.59 ± 0.26	0.10 ± 0.22	1.92	0.070	0.86 ± 0.11	0.62 ± 0.10	0.24 ± 0.09	12.01	<0.001	0.10 ± 0.22	0.24 ± 0.09	0.14 (59.6)	2.63	0.012
Lingual	0.68 ± 0.24	0.54 ± 0.20	0.14 ± 0.23	2.77	0.012	0.84 ± 0.13	0.66 ± 0.12	0.18 ± 0.12	6.99	<0.001	0.14 ± 0.23	0.18 ± 0.12	0.04 (22.2)	0.71	0.485

The remaining dentin thickness of two groups at mesial, distal, buccal and lingual sides of apical third is summarised in Mean ± SD. The pre and post data of each group was compared by paired t test whereas pre to post change (pre-post) between two groups were compared by Student's t test.



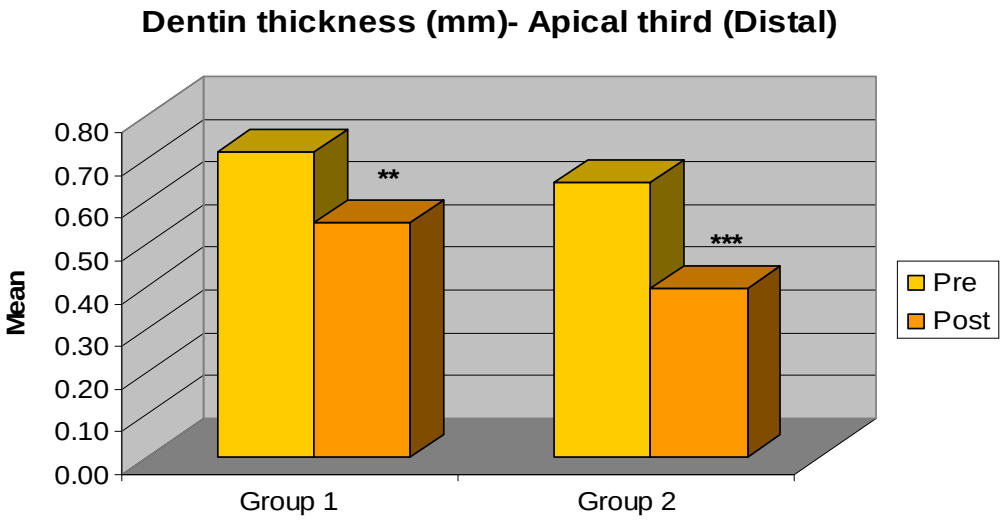
$^{**}p < 0.05$ or $^{***}p < 0.001$- as compared to Pre

Graph 17. For each group, bar graphs showing comparison of difference in pre and post mean dentin thickness at mesial side of apical third. In both groups, the mean dentin thickness at mesial side of apical third decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident slightly higher in Group 2 as compared to Group 1.



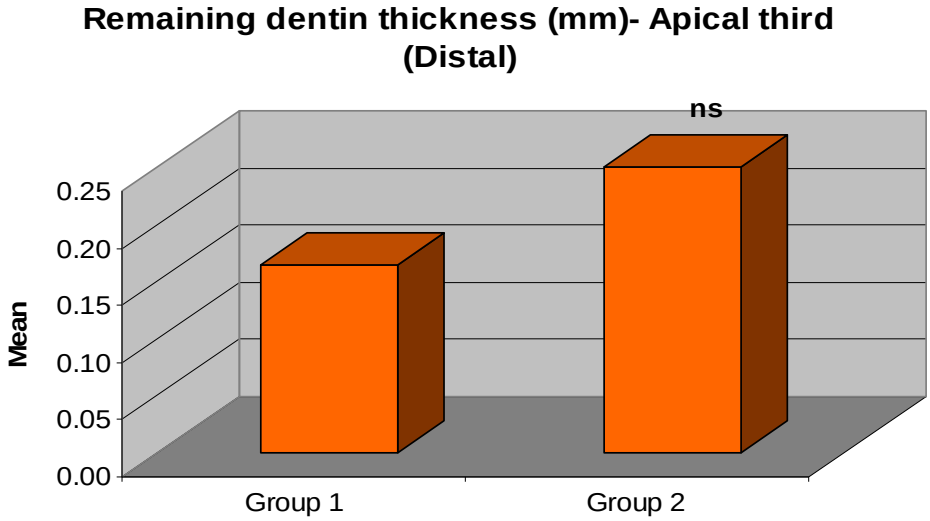
$^{ns}p > 0.05$- as compared to Group 1

Graph 18. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at mesial side of apical third. Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups though it remained 18.5% higher in Group 2 as compared to Group 1



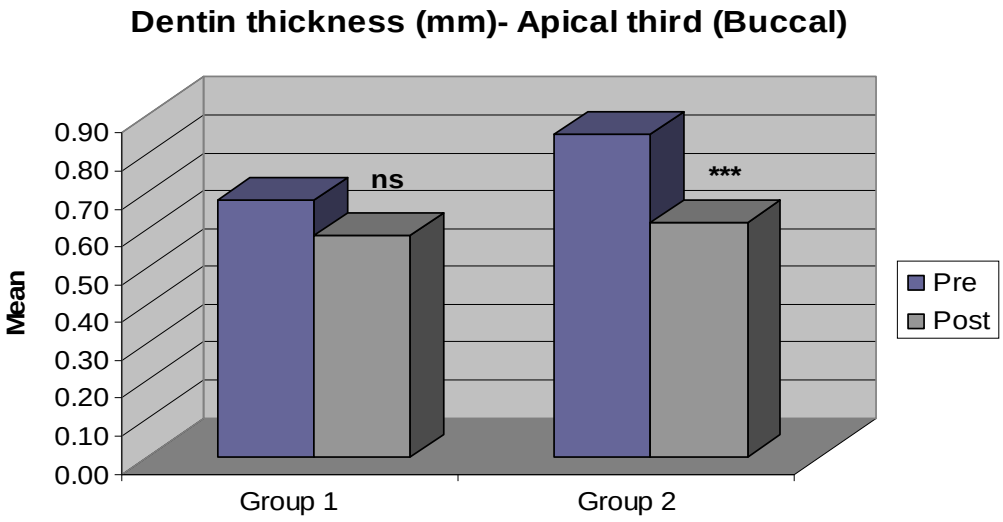
$^{**}p < 0.01$ or $^{***}p < 0.001$- as compared to Pre

Graph 19. For each group, bar graphs showing comparison of difference in pre and post mean dentin thickness at distal side of apical third. In both groups, the mean dentin thickness at distal side of apical third decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident slightly higher in Group 2 as compared to Group 1.



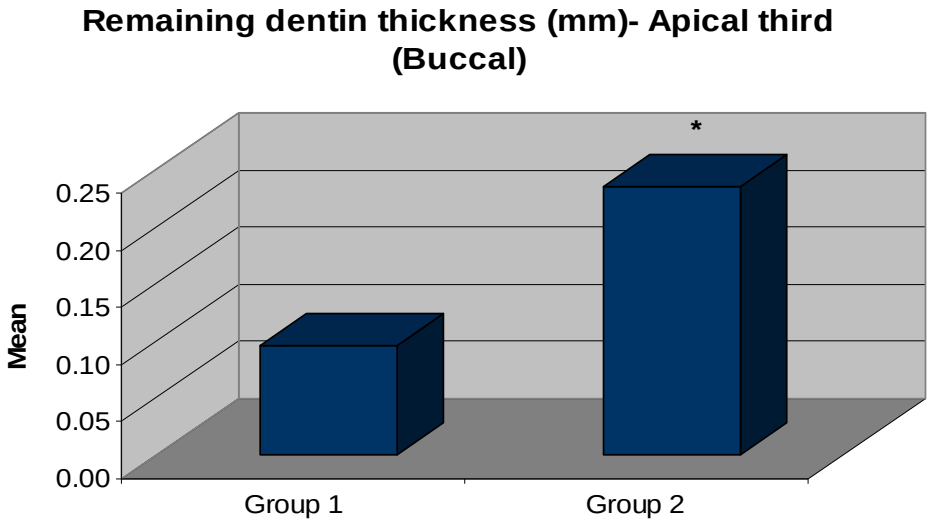
$^{ns}p > 0.05$- as compared to Group 1

Graph 20. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at distal side of apical third. Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups though it remained 34.0% higher in Group 2 as compared to Group 1



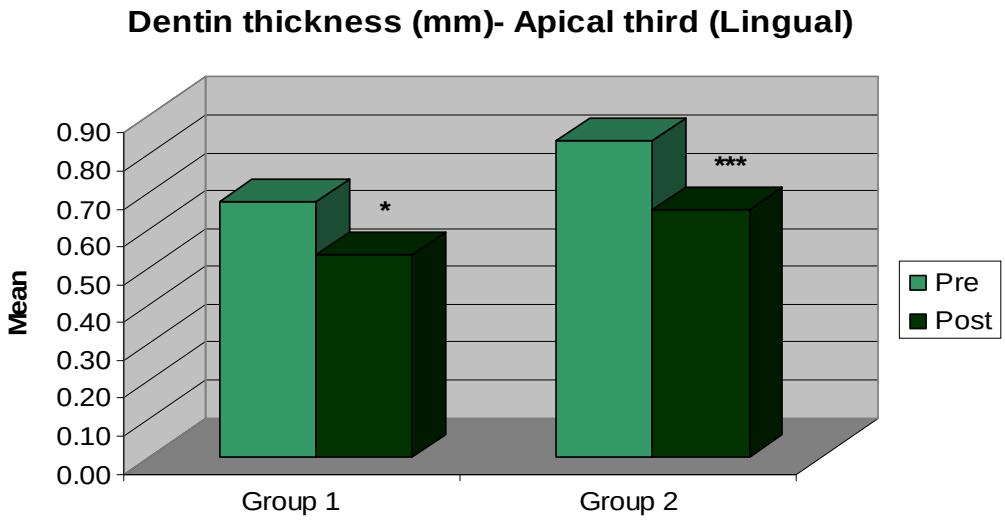
$^{ns}p > 0.05$ or $^{***}p < 0.001$- as compared to Pre

Graph 21. For each group, bar graphs showing comparison of difference in pre and post mean dentin thickness at buccal side of apical third. In both groups, the mean dentin thickness at buccal side of apical third decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident slightly higher in Group 2 as compared to Group 1.



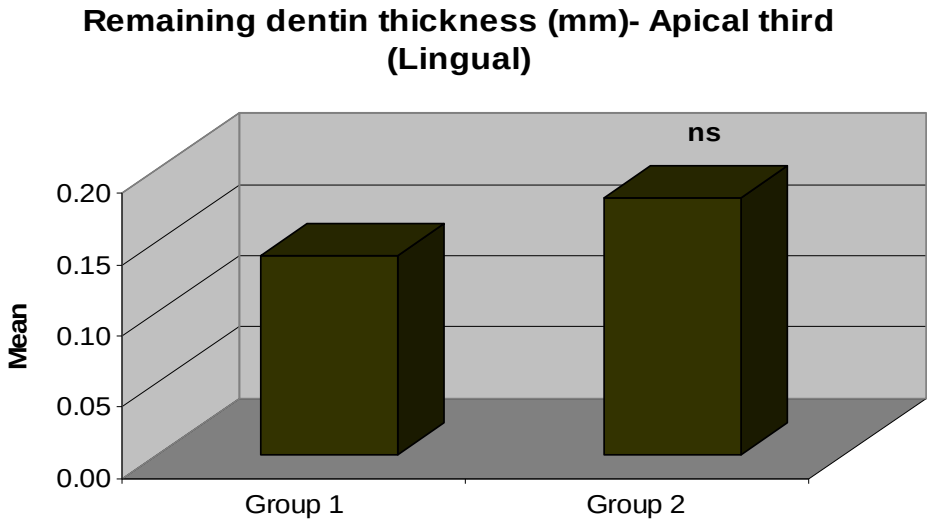
$^{*}p < 0.05$- as compared to Group 1

Graph 22. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at buccal side of apical third. Student's t test showed significantly ($p < 0.05$) different and higher (59.6%) remaining dentin thickness in Group 2 as compared to Group 1



$^{*}p < 0.05$ or $^{***}p < 0.001$- as compared to Pre

Graph 23. For each group, bar graphs showing comparison of difference in pre and post mean dentin thickness at lingual side of apical third. In both groups, the mean dentin thickness at lingual side of apical third decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident slightly higher in Group 2 as compared to Group 1.



$^{ns}p > 0.05$- as compared to Group 1

Graph 24. Bar graphs showing comparison of difference in mean remaining dentin thickness between two groups at lingual side of apical third. Student's t test showed similar ($p > 0.05$) remaining dentin thickness between the two groups though it remained 22.2% higher in Group 2 as compared to Group 1

Total remaining dentin thickness

The total (cervical + middle + apical) remaining dentin thickness of two groups is summarised in Table 4 and also shown in Graph 25-26. In both groups, the mean total dentin thickness decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident comparatively higher in Group 2 as compared to Group 1.

In Group 1, the mean total dentin thickness at pre was 12.24 ± 2.10 mm and at post it was 10.68 ± 1.42 mm. Comparing the pre and post mean total dentin thickness of Group 1, paired t test showed significant ($p < 0.01$) decrease in total dentin thickness at post as compared to pre (12.24 ± 2.10 vs. 10.68 ± 1.42, diff=1.56 ± 2.17, t=3.22, $p = 0.005$) (Table 4 and Graph 25).

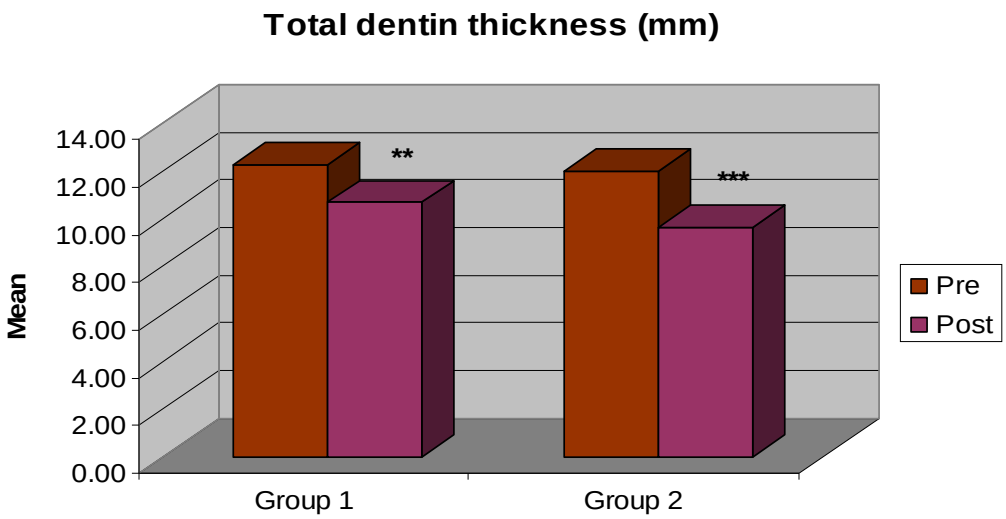
Similarly, in Group 2, it was 11.97 ± 0.53 mm at pre and 9.64 ± 0.53 mm at post and it also decreased significantly ($p < 0.001$) at post as compared to pre (11.97 ± 0.53 vs. 9.64 ± 0.53, diff=2.34 ± 0.40, t=26.43, $p < 0.001$) (Table 4 and Graph 25)

Further, comparing the pre to post mean change in total dentin thickness (i.e. remaining dentin thickness) between two groups, Student's t test showed similar ($p > 0.05$) total remaining dentin thickness between the two groups (1.56 ± 2.17 vs. 2.34 ± 0.40, diff=0.78, t=1.57, $p = 0.124$) though it remained 33.2% higher in Group 2 as compared to Group 1 (Table 4 and Graph 26).

Table 4: Total remaining dentin thickness of two groups

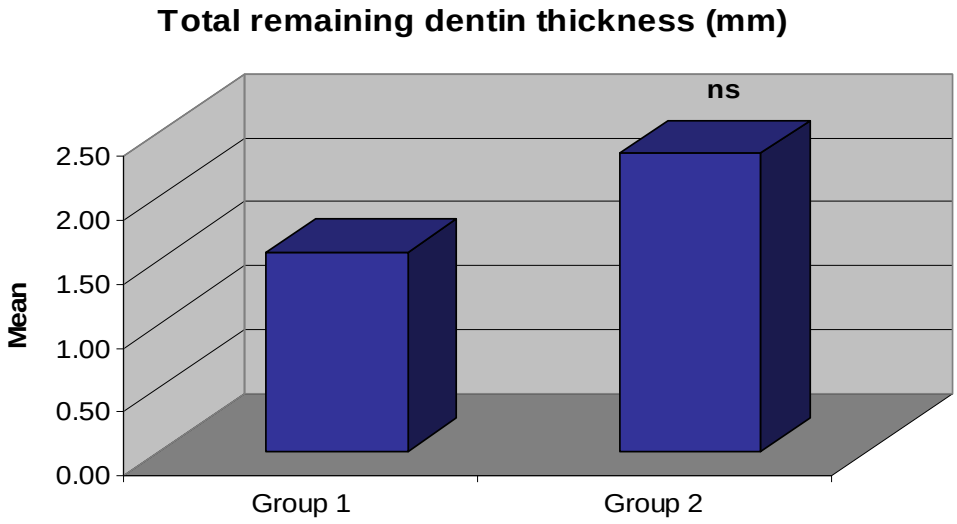
Group	**Pre (n=20)**	**Post (n=20)**	**Change (Pre-Post)**	**t value**	***p* value**
Group 1	12.24 ± 2.10	10.68 ± 1.42	1.56 ± 2.17	3.22	0.005
Group 2	11.97 ± 0.53	9.64 ± 0.53	2.34 ± 0.40	26.43	<0.001
Group 1 vs. Group 2 diff. (%) t value *p* value			0.78 (33.2) 1.57 0.124		

The total remaining dentin thickness of two groups is summarised in Mean ± SD. The pre and post data of each group was compared by paired t test whereas pre to post change (pre-post) between two groups were compared by Student's t test.



$^{**}p < 0.01$ or $^{***}p < 0.001$- as compared to Pre

Graph 25. Bar graphs showing comparison of difference in pre and post mean total dentin thickness of two groups. In both the groups, the mean total dentin thickness decreased (or changed) comparatively at post as compared to pre and the decrease (restoration) was evident comparatively higher in Group 2 as compared to Group 1.



$^{ns}p > 0.05$- as compared to Group 1

Graph 26. Bar graphs showing comparison of difference in mean total remaining dentin thickness between two groups. Student's t test showed similar ($p > 0.05$) total remaining dentin thickness between the two groups though it remained 33.2% higher in Group 2 as compared to Group 1 .

B. Canal volume

The canal volume of two groups is summarised in Table 5 and also shown in Graph 27-28. In both groups, the mean canal volume increased comparatively at post as compared to pre and the increase was evident comparatively higher in Group 1 as compared to Group 2.

In Group 1, the mean canal volume at pre was 5.45 ± 2.46 mm^3 whereas at post it was 7.20 ± 2.19 mm^3. Comparing the pre and post mean canal volume of Group 1, paired t test showed significant ($p < 0.001$) increase in canal volume at post as compared to pre (5.45 ± 2.46 vs. 7.20 ± 2.19, diff=1.75 ± 1.07, t=7.32, $p < 0.001$) (Table 5 and Graph 27).

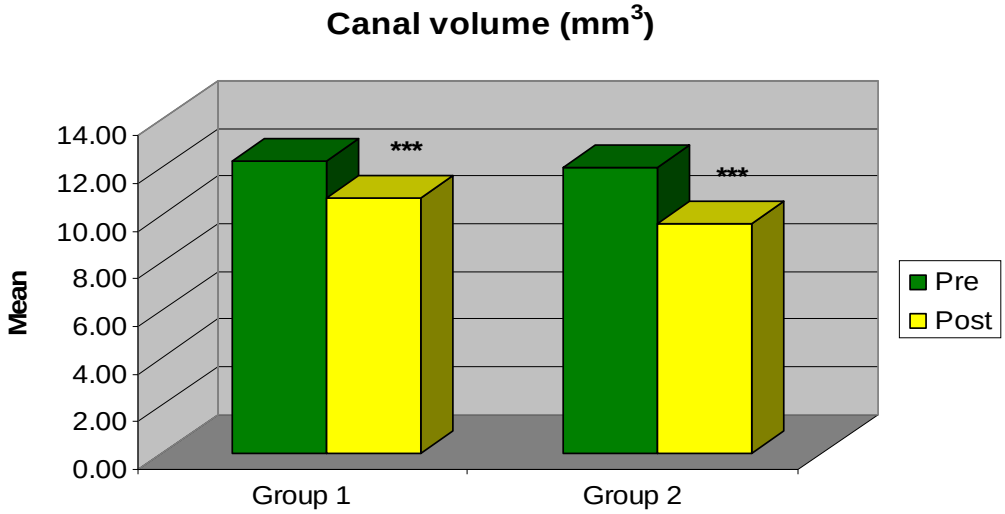
Similarly, in Group 2, it was 6.35 ± 2.62 mm^3 at pre and 7.60 ± 2.48 mm^3 at post and it also increased significantly ($p < 0.001$) at post as compared to pre (6.35 ± 2.62 vs. 7.60 ± 2.48, diff=1.25 ± 0.44, t=12.58, $p < 0.001$) (Table 5 and Graph 27)

Further, comparing the pre to post mean change or net increase in canal volume between two groups, Student's t test showed similar ($p > 0.05$) pre to post increase in canal volume between the two groups (1.75 ± 1.07 vs. 1.25 ± 0.44, diff=0.50, t=1.93, $p = 0.061$) though it was 28.6% higher in Group 1 as compared to Group 2 (Table 5 and Graph 28).

Table 5: Canal volume (mm^3) of two groups

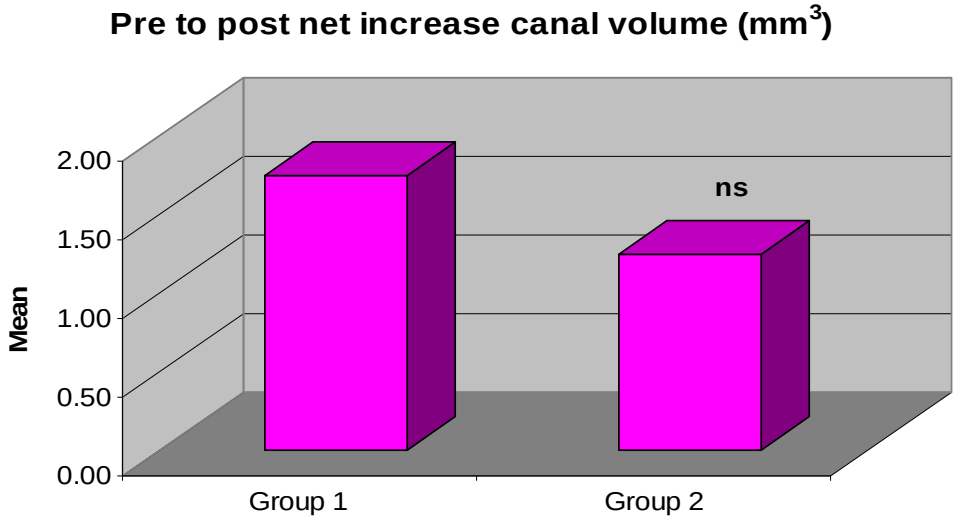
Group	**Pre (n=20)**	**Post (n=20)**	**Change (Post-Pre)**	**t value**	***p* value**
Group 1	5.45 ± 2.46	7.20 ± 2.19	1.75 ± 1.07	7.32	<0.001
Group 2	6.35 ± 2.62	7.60 ± 2.48	1.25 ± 0.44	12.58	<0.001
Group 1 vs. Group 2 diff. (%) t value *p* value			0.50 (28.6) 1.93 0.061		

The canal volume of two groups is summarised in Mean ± SD. The pre and post data of each group was compared by paired t test whereas pre to post change (pre-post) between two groups were compared by Student's t test.



$^{***}p < 0.001$- as compared to Pre

Graph 27. Bar graphs showing comparison of difference in pre and post mean canal volume of two groups. In both groups, the mean canal volume increased comparatively at post as compared to pre and the increase was evident comparatively higher in Group 1 as compared to Group 2.



$^{ns}p > 0.05$- as compared to Group 1

Graph 28. Bar graphs showing comparison of difference in pre to post net mean increase in canal volume between two groups. Student's t test showed similar ($p > 0.05$) pre to post increase in canal volume between the two groups though it was 28.6% higher in Group 1 as compared to Group 2

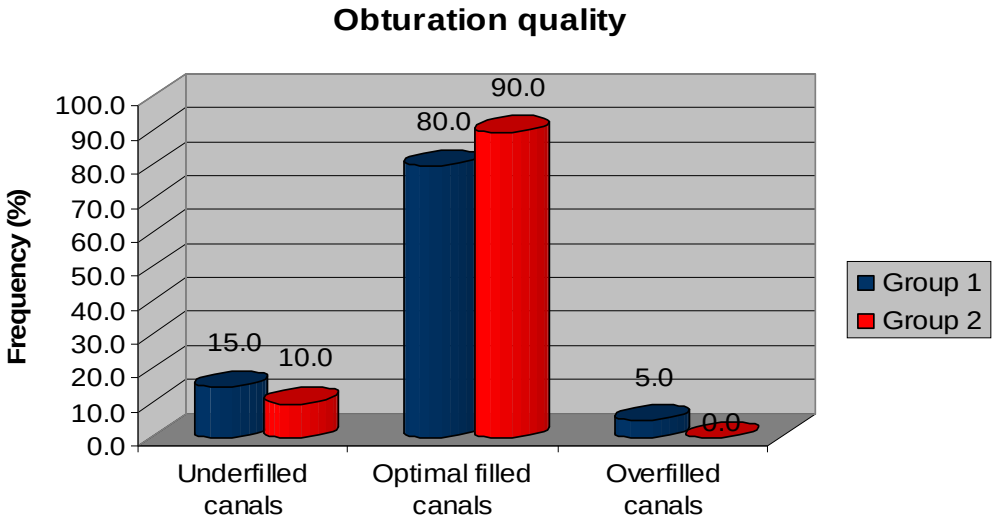
C. Quality of Obturation

The obturation quality (underfilled canals/optimal filled canals/overfilled canals) of two groups is summarised in Table 6 and shown graphically in Graph 29. The both groups showed similar obturation quality. In Group 1, there were 3 (15.0%) samples/cases with underfilled canals, 16 (80.0%) optimal filled canals and 1 (5.0%) overfilled canals whereas it were 2 (10.0%), 18 (90.0%) and 0 (0.0%) respectively in Group 2. Comparing the frequency (%) distribution of obturation quality of two groups, χ^2 test showed similar obturaion quality between the two groups (χ^2=1.32, p = 0.518) i.e. did not differed significantly.

Table 6: Frequency distribution of obturation quality of two groups

Obturation quality	**Group 1 (n=20) (%)**	**Group 2 (n=20) (%)**	**χ^2 value**	***p* value**
Underfilled canals	3 (15.0)	2 (10.0)	1.32	0.518
Optimal filled canals	16 (80.0)	18 (90.0)		
Overfilled canals	1 (5.0)	0 (0.0)		

The obturation quality of two groups were summarised in number (n) and percentage (%) and compared by χ^2 test.



Graph 29. Bar graphs showing distribution of quality of obturation of two groups. Comparing the frequency (%) distribution of obturation quality of two groups, χ^2 test showed similar obturation quality between the two groups did not differ significantly.

DISCUSSION

Pulpectomy is a therapeutic option for painful primary teeth with radicular pulp necrosis or chronic inflammation. (Pinkham and Casamassimo 2005).[26] Pulpectomy includes complete pulpal tissue debridement, and preparation of canal, followed by obturation with a biocompatible and resorable material. In the literature, hand files are the traditional approach of cleaning and shaping the canals in primary teeth. For years, hand K files have been used to prepare root canals in both primary and permanent teeth. Despite the fact that it is the most frequently approved and utilised method for canal debridement and shaping, hand instrumentation is time consuming and can result in iatrogenic errors. Both the dentist and the patient found hand K files to be tiring. In paediatric patients, the downsides, such as discomfort and longer chair side time, lead to uncooperative behaviour. Endodontic treatment is more difficult and time consuming using traditional hand files due to the tortuous path of root canals in primary teeth.

In recent years, many Ni-Ti file systems have been created to enhance the canal shaping technique. Ni-Ti files have become popular because to their great flexibility and ability to follow the natural root canal structure. The key benefit of these files is the decrease in endodontic errors owing to instrument separation, which is primarily due to the avoidance of continuous dentinal over engagement.[27] The file systems also have the additional advantage of reducing working time and ensuring the performance of the shaping procedure. When it comes to treating children, all of these factors become much more crucial.[28]

This was an *in-vitro* study that dealt with comparative evaluation of cutting efficacy of manual and rotary file systems in primary teeth. According to the formula, a total of 40 extracted anterior teeth were divided into two groups and randomised equally. The outcome measures of the study were remaining dentin thickness, canal volume and quality of obturation. All outcome measures were evaluated both before and after treatment.

The quantity of dentin removed and the aggressiveness of the root canal instrument have a positive association.[29] An adequate quantity of preserved dentin

thickness is essential to provide enough resistance to lateral and occlusal pressures for an endodontically treated tooth.[20]

In the present study, dentin thickness was evaluated at three levels from the cervical level to the apex of the canal at equal intervals. Maxillary and Mandibular anteriors were selected for the study to maintain uniformity straight canals were assessed, thus they were accepted. In the study, efficient CBCT imaging provides a viable and non-destructive approach for assessing canal shape before and after canal preparation.[30]

In both the groups, the mean dentin thickness at each side of coronal, middle and cervical third decreased (or changed) comparatively at post as compared to pre and it remained 33.2% higher in Group 2 as compared to Group 1. It can be seen as cleaning and shaping of root canals leads to better removal of debris as well as unsupported dentin.[31]

The root of primary teeth is shorter, thinner, and more curved than permanent teeth's root, with root tip resorption. Painless and efficient, with minimal treatment time and adequate root canal debridement without compromising tooth structure, a successful pulpectomy procedure for primary teeth should be used.

On comparing the pre to post mean change in dentin thickness between two groups, remaining dentin thickness between the two groups remained 22.7% higher in Group 2 as compared to Group 1. It is evident that the intensive canal preparation due to hand instrumentation leads to more loss of dentin. It was a similar finding as Shahriar et al (2009), [37] the thickness of dentin removed varies significantly between the two techniques. In the hand instrumentation group, significantly greater dentin was removed in all sites. This study found that at all levels Stainless Steel hand instrumentation removed more dentin than Ni-Ti rotary instrumentation. This finding is in line with previous research that reported Ni-Ti rotary files suitable of preparing curved root canals with superior tooth structure preservation.

Nagaratna et al. (2006), [32] compared the taper of Hand K and rotary file preparations in primary teeth, having found that rotary files provided significantly better preparation and less dentin removal than Hand K files. It came to the same conclusion as the current study.

In a study by Kummer et al. (2008), [33] it was observed that instrumentation with hand K files removed more dentin as compared to rotary instrumentation, except at the apical third. This study's findings were similar to the present research, in that Hand K files removed more dentin in our comparison.

The exclusive pediatric rotary file, Kedo-S file system (Reeganz Dental Care Pvt. Ltd. India) was introduced (Jeevanandan 2017) [34]. It consists of three Ni–Ti files (D1, E1, U1) for use only in primary teeth. The presence of variably varying taper is another hallmark of these files. The D1 and E1 files have a tip diameter of 0.25 and 0.30 mm, respectively, and were developed for molar instrumentation. The D1 file contains 4, 5, 6, 8% tapers in various lengths, allowing it to be utilised exclusively in primary molar canals that are narrower, such as the mesiobuccal and mesiolingual canals. E1 file has 4, 6, 8% tapers in different length corresponding to be used in wider canals in primary molars namely distal canal(s).

In the present study, U1 Kedo S files were used for the anterior teeth canal preparation of rotary groups canals as recommended by manufacturers' and were compared with the standard method of preparing the canals with stainless steel K-files (15–40). Due to its form memory capability, Ni–Ti rotary instruments can produce curved canal(s) with minimum canal transit. When compared to stainless steel files, Ni–Ti instruments have more flexibility and are more resistant to torsional fracture. Due to the obvious flexibility of Ni–Ti rotary files, the dentist can use them more confidently in a curved root canal (s)

In this study, Kedo-S paediatric rotary files were tested to see if the newly developed customized rotary files for primary teeth with a shorter length and adjusted taper might be a viable alternative to existing adult rotary files and traditional stainless steel K files for primary teeth. This study has the benefit of using a three-dimensional CBCT evaluation technique to determine the residual dentin thickness.

There were also a few studies that found no difference in rotary and manual instrumentation. In primary molars, Silva et al. (2003) [35] compared the cleaning ability of rotary technique to manual instrumentation. There were no significant differences between them in the results.

There is a plethora of info out there about using NiTi files for endodontic treatments. Nagaratna et al. (2006), [32] also found that with the ProFile method, it was also discovered that the canal preparation had an acceptable taper and smooth walls; nevertheless, instrument breakage was recorded. The present study used single file rotary system which have yielded similar results with other rotary systems in permanent and primary root canals and also demonstrated better cutting efficacy and their ability to preserve working length and canal curvature in shorter time, to simplify the root canal instrumentation.

In both the groups, the mean canal volume increased comparatively at post as compared to pre and the increase was evident comparatively higher in Group 1 as compared to Group 2. The pre to post increase in canal volume between the two groups was 28.6% higher in Group 1 as compared to Group 2.

The present study demonstrated a significant increase in the volume of the canals post-instrumentation. Further, comparison of the instrumentation techniques presented a statistically significant difference, wherein manual system showed increase in the volume of the preparation compared to rotary files. It is evident that increase in canal volume would definitely remove the infected dentin effectively but also can lead to early exfoliation of tooth. [36]

The ribbon shape of the root canals in primary teeth, with a narrow mesiodistal width compared to their buccolingual dimension, discourages gross enlargement of the canals, according to Curzon(2005). [36]

In permanent teeth, the object of mechanical preparation is to provide an even, circular, apical one-third of the canal which will be obturated with an accurately fitting master point. On the contrary in primary tooth, attempts to prepare a circular apical one-third mechanically may result in lateral perforation of the canal because of its hourglass shape.[28]

Azar et al. (2011), [38] concluded that, in both primary and permanent teeth, the Mtwo rotary device demonstrated adequate cleaning capabilities and obtained results comparable to K-files in less time. Also, Kummer et al. (2008) [33] observed that the Hero 642 rotary instrumentation removed less dentin and led to more uniform root

canal preparation in primary teeth than by hand files. This difference could be due to varied tools used for investigation.

In the present study, the obturation quality (underfilled canals/optimal filled canals/overfilled canals) of two groups is also evaluated and it was found that both the groups showed similar obturation quality. The volumetric analysis was done before and after obturation for quality of filling. In this study, standardization was maintained by using a common biomechanical procedure and obturating material of same radio-opacity and consistency. Metapex is easily available, widely used, and one with a moderate to high success rate. An acceptable obturation technique is the one which shows optimal filling. There are many goals for pulpectomy operations in primary teeth; one is that radiographic evidence of effective filling without severe overextension or underfilling should be present.

Due to the possibility of extruding the filling material beyond the root and inducing irritation, pulpectomies filled short or to the apex had a substantially higher survival rate than overfilled canals, as per studies. Whereas Bawazir et al. (2006) [39] reported that overfilled and properly filled root canals had significantly higher radiographic success rates than underfilled. Nevertheless, overfilling should not be recommended over an optimally filled root canal. Potential drawbacks of overfilling are foreign body reaction or deflection of the unerupted permanent tooth.

In the present study, volumetric analysis was done for quality of obturation using CBCT. As clinical radiographs are only 2 Dimensional reproductions, the radiographic monitoring of root canal treatment is challenging because of the difficulties in distinguishing features superimposed onto each other.[40]

Radiographs illustrate image only two dimensionally. The disadvantage with sectioning is that it could result in loss of tooth material. A literature search revealed that only sectioning studies have been undertaken to assess root canal preparation and cleaning efficacy at various levels in primary teeth. CBCT is a non-invasive technique and gives a 3-dimensional interpretation at various levels, avoids loss of material, yields reproducible results, and the specimens can be used for further research. Added to these, the specific location of dentin thickness can be determined accurately. Hence, CBCT was chosen as the tool for investigating the efficacy of preparation, and further without loss of specimen, the samples were utilized for evaluating the volume

of root canal filling. Song et al. reported that C.B.C.T is superior to periapical radiograph in evaluating the apical extension of root canal obturation.

CONCLUSIONS

The present *in-vitro* study was performed for comparative evaluation of cutting efficiency in manual and rotary file system for primary teeth. Total 40 extracted teeth were collected and examined. The study was conducted in the Department of Paediatric and Preventive Dentistry, Babu Banarasi Das College of Dental Sciences, Lucknow after obtaining clearance from institutional ethical committee of BBDCODS, Lucknow. The following observations made from the current study's experimental conditions:

- The dentin thickness at the buccal surface of the root of cervical third and apical third showed significant difference between manual and rotary file system.
- The dentin thickness of mesial, distal and lingual surfaces of cervical and apical third did not show significant differences.
- The distal surface of middle third showed similar remaining dentin thickness in both the groups.
- The two file systems did not show any statistically significant differences at middle third for remaining dentin thickness.
- Canal volume of the preparations increased more in hand instrumentation group than in the rotary group.
- The obturation quality did not show any difference in either of the groups.

BIBLIOGRAPHY

1. Comparative Evaluation of Efficiency of Different File Systems in Terms of Remaining Dentin Thickness Using Cone-Beam Computed Tomography: An In vitro Study; Nidhi Rathi Chaudhary ,Contemp Clin Dent. 2018 Jul-Sep; 9(3): 367–371.
2. Craig and Peyton,Physical properties of stainless steel files and reamers; oral surg:16:206;1963,
3. Walia HM, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of Nitinol root canal files. *J Endod.* 1988;14:346–51.
4. Szep S, Gerhardt T, Leitzbach C, Lüder W, Heidemann D. Preparation of severely curved simulated root canals using engine-driven rotary and conventional hand instruments; *Clin Oral Investig.* 2001;5:17–25
5. Javaheri HH, Javaheri GH. A comparison of three Ni-Ti rotary instruments in apical transportation. *J Endod.* 2007;33:284–6.
6. Barr ES, Kleier DJ, Barr NV. Use of nickel-titanium rotary files for root canal preparation in primary teeth. Pediatr Dent. 2000;22(1):77-78.
7. Govindaraju L, Jeevanandan G, Subramanian E. Knowledge and practice of rotary instrumentation in primary teeth among Indian dentists: a questionnaire survey. J Int Oral Health. 2017;9:45–8
8. Pruett JP, Clement DJ, Carnes DL., Jr Cyclic fatigue testing of nickel-titanium endodontic instruments. *J Endod.* 1997;23:77–85.
9. Nagaratna PJ, Shashikiran ND and Subbareddy VV.In vitro comparison of NiTi rotary instruments and stainless steel hand instruments in root canal preparations of primary and permanent molar. J Indian Soc Pedod Prev Dent 2006: 186-191.
10. S.CRESPO,O.CORTES,C GRACIA,L PEREZ. Comparison between rotary and manual instrumentation in primary teeth. *J clin pediatr den* 2008;32(4):295-98
11. Romero TO, Gonzalez VM, Reyes HF, Guillen AP. Comparison between rotary and manual techniques on duration of instrumentation and obturation times in primary teeth. *J Clin Pediatr Dent* 2011; 35:359-63.

12. Pinheiro SL, Neves LS, Imparato JP, Duarte DA, Bueno CE, Cunha RS. Analysis of the instrumentation time and cleaning between manual and rotary techniques in deciduous molars. *Revista Sul-Brasileira de odontologia South Brazilian Dentistry Journal* 2012*;* 9:238-44.
13. Govindraju LAVANYA, Jeevanandan GANESH, Subramanian EMG. Clinical evaluation of quality of obturation and instrumentation time using two modified rotary file systems with manual instrumentation in primary teeth. *J Clin Diagn Res* 2017;Sep;11(9):ZC55-ZC58.
14. Reciprocating vs Rotary Instrumentation in Pediatric Endodontics: Cone Beam Computed Tomographic Analysis of Deciduous Root Canals using Two Single-file Systems; Attiguppe R Prabhakar;International Journal of Clinical Pediatric Dentistry 9(1):45-49; March 2016
15. Govindraju LAVANYA, Jeevanandan GANESH, Subramanian EMG..Comparison of quality of obturation and instrumentation time using hand files and two rotary file systems in primary molars:Asingle blinded randomized controlled trial. *Eur j den* 2017;11:376-79.
16. ColomboMARCO, Bassi CRISTINA, Beltrami RICCARDO, Vigorelli PAOLO, SpinellI A , Cavada ANDREA et al Radiographic technical quality of root canal treatment performed by a new rotary single-file system. *Ann Stomatol* (Roma). 2017 Jan-Mar; 8(1): 18–22.
17. Musale PK, Jain KR, Kothare SS. Comparative assessment of dentin removal following hand and rotary instrumentation in primary molars using cone-beam computed tomography. J Indian Soc Pedod Prev Dent 2019;37(1):80–86. DOI: 10.4103/JISPPD.JISPPD_210_18.
18. Lim SS, Stock CJ. The risk of perforation in the curved canal: Anticurvature filing compared with the stepback technique. Int Endod J 1987;20(1):33–39. DOI: 10.1111/j.1365-2591.1987.tb00586.x.
19. Reddy J et al (2018); Comparative analysis of efficacy and cleaning ability of hand and rotary devices for gutta-percha removal in root canal retreatment: an in vitro study; J Contemp Dent Pract; 2013 Jul 1;14(4):635-43
20. Thakur Seema, Haseeb Ahammed, Singhal Parul, Jayam Cheranjeevi; Comparative Evaluation of Dentin Removal and Taper of Root Canal Preparation of Hand K File, ProTaper Rotary File, and Kedo S Rotary File in

Primary Molars Using Cone-beam Computed Tomography; International Journal of Clinical Pediatric Dentistry, Volume 13 Issue 4 (July–August 2020)

21. Berutti E, Chiandussi G, Paolino DS, Scottin N, Cantatore G, Castellucci A, Pasqualini D. Canal shaping with wave one primary reciprocating files and protaper system. J Endod 2012 Apr;38(4):505-509.
22. De-Deus G, Moreira EJ, Lopes HP, Elias CN. Extended cyclic fatigue life of F2 ProTaper instruments used in reciprocating movement. Int Endod J 2010 Dec;43(12):1063-1068.
23. Gutmann JL, Gao Y. Alteration in the inherent metallic and surface properties of nickel-titanium root canal instruments to enhance performance, durability and safety: A focused review. *Int Endod J.* 2012;45:113–28.
24. Pinkham and Casamassimo; Pediatric Dentistry;5th Edition: Infancy through Adolescence2005
25. Haapasalo M, Shen Y. Evolution of nickel-titanium instruments: From past to future. *Endod Topics.* 2013;29:3–17.
26. Peters OA, Gluskin AK, Weiss RA, Han JT. An *in vitro* assessment of the physical properties of novel Hyflex nickel-titanium rotary instruments. *Int Endod J.* 2012;45:1027–34.
27. Kaval ME, Capar ID, Ertas H. Evaluation of the cyclic fatigue and torsional resistance of novel nickel-titanium rotary files with various alloy properties. *J Endod.* 2016;42:1840–3.
28. Liu Z, Liu J, Gu L, Liu W. The shaping and cleaning abilities of self-adjusting files in the preparation of canals with isthmuses after glidepath enlargement with ISO or ProTaper Universal NiTi files. *J Dent Sci.* 2016;11:83–9.
29. Singh H, Kapoor P. Hyflex CM and EDM files: Revolutionizing the art and science of endodontics. *J Dent Health Oral Disord Ther.* 2016;5:00182
30. Gluskin AH, Brown DC, Buchanan LS. Are constructed computerized tomographic comparison of Ni-Ti rotary GT files versus traditional instruments in canals shaped by novice operators. Int Endod J. 2001;34:476-84.
31. Zuckerman O, Katz A, Pilo R, Tamse A,Fuss Z. Residual dentin thickness in mesial rootsof mandibular molars prepared with Lightspeedrotary instruments

and Gates-Glidden reamers.Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 2003;96:351-5.

32. Nagaratna PJ, Shashikiran ND and Subbareddy VV.In vitro comparison of NiTi rotary instruments and stainless steel hand instruments in root canal preparations of primary and permanent molar. J Indian Soc Pedod Prev Dent 2006: 186-191.
33. Kummer TR, Calvo MC, Cordeiro MM, et al. Ex vivo study of manual and rotary instrumentation techniques in human primary teeth. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 2008;105(4):84–92. DOI: 10.1016/j.tripleo.2007.12.008.
34. Jeevanandan G. Kedo-S paediatric rotary files for root canal preparation in primary teeth – Case report. J Clin Diagn Res 2017;11:ZR03-5.
35. Silva L.A., Leonardo M.R., Nelson-Filho P., Tanomaru J.M. Comparison of rotary and manual instrumentation techniques on cleaning capacity and instrumentation time indeciduous molars. *J. Dent. Child.* 2004;71:45–47.
36. Curzon In vitro comparison of Ni Ti rotary instruments and stainless steel hand instruments in root canal preparation of primary and permanent molars. *J. Indian Soc. Pedod. Prev. Dent.* 2006;24:186–191.
37. Shahriar, Delschen S., Stachniss V. Root canal shaping with manual and rotary NiTi file performed by students. Iranian Endodontic Journal 4(2):69-73;2009;36:715–723
38. Azar Muhammed Reza, Safi Laya, Nikaein Afshin. Comparison of the cleaning capacity of MTWO Pro Taper and rotary systems and manual instruments in primary teeth. *Dent. Res. J.* 2012;9:146–151.
39. Clinical Evaluation of Root Canal Obturation Methods in Primary Teeth Omar A. Bawazir, Fouad S. Salama; Pediatric Dentistry; Clinical Evaluation of Root Canal Obturation Method: 28:1 2006
40. Mani SA, Chawla HS, Tewari A, Goyal A. Evaluation of calcium hydroxide and zinc oxide eugenol as root canal filling materials in primary teeth. J Dent Child 2000;67:142-147, 183.

Babu Banarasi Das University
Babu Banarasi Das College of Dental Sciences,
BBD City, Faizabad Road, Lucknow – 226028 (INDIA)

Dr. Lakshmi Bala
Professor and Head Biochemistry and
Member-Secretary, Institutional Ethics Committee

Communication of the Decision of the VIIth Institutional Ethics Sub-Committee

IEC Code: 31 **BBDCODS/01/2019**

Title of the Project: A Comparative Evaluation of Manual and Rotary Files in Primary Teeth.

Principal Investigator: Dr. Nupur **Department:** Paedodontics & Preventive Dentistry

Name and Address of the Institution: BBD College of Dental Sciences Lucknow.

Type of Submission: New, MDS Project Protocol

Dear Dr. Nupur,

The Institutional Ethics Sub-Committee meeting comprising following four members was held on 10th January 2019.

1.	Dr. Lakshmi Bala Member Secretary	Prof. and Head, Department of Biochemistry, BBDCODS, Lucknow
2.	Dr. Amrit Tandan Member	Prof. & Head, Department of Prosthodontics and Crown & Bridge, BBDCODS, Lucknow
3.	Dr. Rana Pratap Maurya Member	Reader, Department of Orthodontics & Dentofacial Orthopedics, BBDCODS, Lucknow
4.	Dr. Sumalatha M.N. Member	Reader, Department of Oral Medicine & Radiology, BBDCODS, Lucknow

The committee reviewed and discussed your submitted documents of the current MDS Project Protocol in the meeting.
The comments were communicated to PI thereafter it was revised.

Decisions: The committee approved the above protocol from ethics point of view.

Forwarded by:

Lakshmi Bala
7/1/19

Member-Secretary
Institutional Ethic Committee
College of Dental Sciences
BBD University
Faizabad Road, Lucknow-226028

(Dr. Lakshmi Bala)
Member-Secretary,
IEC

(Dr. B. Rajkumar)
PRINCIPAL Principal
Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow-
BBDCODS

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES (FACULTY OF BBD UNIVERSITY), LUCKNOW

INSTITUTIONAL RESEARCH COMMITTEE APPROVAL

The project titled **"A Comparative Evaluation of Manual and Rotary Files in Primary Teeth."** submitted by **Dr Nupur** Post graduate student from the **Department of Paedodontics & Preventive Dentistry** as part of MDS Curriculum for the academic year 2018-2021 with the accompanying proforma was reviewed by the Institutional Research Committee present on **27th November 2018** at BBDCODS.

The Committee has granted approval on the scientific content of the project. The proposal may now be reviewed by the Institutional Ethics Committee for granting ethical approval.

Prof. Vandana A Pant
Co-Chairperson

Prof. B. Rajkumar
Chairperson

Formula used for the analysis

Arithmetic Mean

The most widely used measure of central tendency is arithmetic mean, usually referred to simply as the mean, calculated as

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

Standard deviation and standard error

The standard deviation (SD) is the positive square root of the variance, and calculated as

$$SD = \sqrt{\frac{\sum X_i^2 - \frac{(\sum X_i)^2}{n}}{n-1}}$$

and SE (standard error of the mean) is calculated as

$$SE = \frac{SD}{\sqrt{n}}$$

where, n= no. of observations

Minimum and Maximum

Minimum and maximum are the minimum and maximum values respectively in the measure data and range may be dented as below

Range = Min to Max

and also evaluated by subtracting minimum value from maximum value as below

Range = Maximum value-Minimum value

Median

The median is generally defined as the apical measurement in an ordered set of data. That is, there are just as many observations larger than the median as there are smaller. The median (M) of a sample of data may be found by first arranging the measurements in order of magnitude (preferably ascending). For even and odd number of measurements, the median is evaluated as

M= [(n+1)/2]th observation- odd number

M= [n(n+1)/2]th observation – even number

Paired t-test

Paired t-test was used to calculate the differences between two paired samples i.e. when in each observation in Sample 1 is in some way correlated with an observation in Sample 2, so that the data may be said to occur in pairs and calculated as

$$t = d/Sd$$

where, d is the mean of difference within each pair of measurements and Sd the standard error of the difference. The degrees of freedom (DF) is calculated as

$$DF = n-1$$

Student's t Test

Student's t-test was used to calculate the differences between the means of two groups

$$t = \frac{\bar{X}_1 - \bar{X}_2}{}$$

where,

$$SE = \sqrt{S^2 X \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}$$

SE

S^2 is the pooled variance and n1 and n2 are number of observations in group 1 and 2 respectively. The degrees of freedom (DF) is calculated as

$$DF = n1 + n2 - 2$$

Chi-square test

The chi-square (χ^2) test is used to compare the categorical data as

$$\chi^2 = \Sigma\Sigma \frac{(Fij - fij)^2}{fij}$$

where, Fij is the observed frequency while fij the expected frequency. The degrees of freedom (DF) is calculated as

$$DF = (r-1)\,(c-1)$$

Statistical significance

Level of significance "*p*" is the probability signifies level of significance. The mentioned p in the text indicates the following:

$p > 0.05$- not significant (ns)

$p < 0.05$- just significant (*)

$p < 0.01$- moderate significant (**)

$p < 0.001$- highly significant (***)

Curigional

Document Information

Analyzed document	Dr. Nupur.docx (D110223861)
Submitted	7/7/2021 5:48:00 AM
Submitted by	Dr. Nupur
Submitter email	1180327002@bbdu.ac.in
Similarity	8%
Analysis address	1180327002.bbduni@analysis.urkund.com