AN IN VITRO STUDY TO COMPARE THE DENTINAL DEFECTS CAUSED DURING ROOT CANAL PREPARATION WITH HAND FILE AND TWO DIFFERENT Ni-Ti ROTARY FILE SYSTEMS

Dissertation submitted to

THE TAMIL NADU Dr. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment for the degree of

MASTER OF DENTAL SURGERY

BRANCH IV

CONSERVATIVE DENTISTRY AND ENDODONTICS

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Date: 18.1.2018

Place: Tiruchengode

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PLACE OF STUDY	VIVEKANANDHA DENTAL COLLEGE FOR WOMEN, TIRUCHENGODE.
DURATION OF THE COURSE	3 YEARS (2015-2018)
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CONTENTS

INTRODUCTION

Richard Bence defines endodontics as the speciality of dentistry concerned with the diagnosis and treatment of diseases and injuries of the pulp and periapical tissues. [1]

In 1987, American Association of Endodontists defines endodontics is a branch of dentistry concerned with the morphology, physiology and pathology of the human dental pulp and peri-radicular tissues. [1]

Treating vital and necrotic dental pulps through endodontic therapy, patients can retain their natural teeth in function and esthetics. Root canal preparation is one of the most important steps in root canal treatment which determines the efficacy of the mechanical debridement, creation of space for medicament delivery and optimized canal geometries for adequate obturation.[2]

Root canal treatment is a procedure that is very frequently performed in dentistry with the aim of retaining teeth. As a treatment option, it offers an alternative to tooth extraction and is carried out on teeth in which irreversible pulpitis has led to necrosis of the dental pulp. [3]

Root canal therapy may be divided arbitrarily into three phases: (1) mechanical preparation; (2) chemical preparation; (3) chemical (or electro chemical) disinfection. Mechanical preparation is often carried out simultaneously with chemical preparation. Disinfection follows only after the canal has been thoroughly cleansed and prepared. [4]

Success in endodontic therapy rests on the pedestal of the endodontic triad "diagnosis +anatomy + debridement = success", with debridement of the canal system through proper cleaning and shaping being of paramount importance in successful treatment. [5]

One of the main steps in achieving endodontic success is biomechanical preparation. This is done by endodontic instruments and irrigating solutions which enables bacterial elimination, removal of debris and facilitates obturation. [6]

The combination of the use of contemporary available modern devices and files with a solid base of anatomic and biologic knowledge will lead to a predictable higher quality of root canal treatment. Cleaning, shaping and obturation of the root canal are the main factors responsible for the success of root canal treatment. [7]

Chemomechanical preparation of the root canal system is a crucial step when performing root canal therapy. Its main purpose is to eliminate organic tissue and reduce the microbial load. [8]

The primary objective of endodontic treatment is to retain the remaining tooth or root structure after decay or trauma in order to ensure, the preserved structure and subsequent restoration are both functional and esthetic. One of the key steps to ensure the success of endodontic therapy or root canal treatment is canal preparation because it determines the effectiveness of all the following procedures such as debridement of the root canal; provision of space for medication delivery; and most importantly, creation of canal geometries for efficient obturation. Root canal anatomy and canal preparation instruments affect the outcome of endodontic treatment. [9]

So the fundamental aim of endodontic treatment is to prevent or cure apical periodontitis. One of the main procedure for achieving endodontic success is root canal preparation by suitable endodontic instruments. It enables the elimination of bacteria, debris removal and facilitating obturation.

Root canal shaping, a contributing factor to the induction of dentinal defects and instrumentation to the apical foramen (AF) has been speculated to increase the risk of producing defects in apical root dentin. [10]

Endodontically treated teeth have a long term functional survival rate, but they are more susceptible to fractures as compared to teeth with vital pulp. Some complications may be encountered during root canal preparation like perforations and microcracks. Root fracture might occur as a result of a microcrack or craze line that propagates with repeated stress by occlusal forces.

The aim of root canal preparation is to shape and clean the root canal system effectively whilst maintaining the original configuration without creating any iatrogenic events such as instrument fracture, external transportation, ledge or perforation. Preparation of the root canal system is recognized as being one of the most important stages in root canal treatment which includes both enlargement and shaping of the complex endodontic space together with its disinfection. A different variety of instruments and techniques have been developed and described for this critical stage of root canal treatment. [11]

During biomechanical preparation, a canal is shaped by the contacts of instruments and root dentinal walls. These contacts create many momentary stress concentrations in dentin. These stress concentrations produce dentinal defects and microcracks which in turn, were associated with increased vertical root fracture susceptibility. Applied stresses caused by root canal obturation, retreatment, and repeated occlusal forces, can be amplified at the tip of those defects and can initiate or propagate into cracks. [12]

Root canal preparation is one of the most important stages in successful root canal treatment and can result in some complications such as perforations, canal transportation, ledge and zip formation and separation of instruments. Vertical root fracture is a clinical complication that can lead to extraction of tooth. Preparation procedures can damage the root dentin, resulting in dentinal cracks that have the potential to develop into vertical root fractures. [13]

Advancements in rotary nickel-titanium (NiTi) instruments have led to new design concepts and techniques for canal preparation. However, canal preparation with larger tapered rotary Ni-Ti instruments involves more dentin removal which compromises the fracture strength of the roots and can induce fractures whether complete or incomplete. Forces that are generated during instrumentation are linked to an increased risk of root fracture which is one of the frustrating complications of root canal treatment that leads to tooth extraction. The root fracture occurs as a result of micro cracks or craze line that propagates with repeated stress application by occlusal forces. [6]

A cracked tooth represents a diagnostic and restorative challenge to clinicians. Clinically, microorganisms may proliferate into crack lines, leading to the establishment of biofilms on the root surface. Additionally, the propagation of a micro crack may lead to a vertical root fracture and ultimately tooth loss.[10]

Coronal and radicular tooth structure loss predisposes endodontically treated teeth to fracture, due to prior pathology or endodontic and/or restorative treatment procedures. Endodontic procedures might also influence fracture patterns as well as other defects, such as craze lines or partial cracks, which have the potential to lead to vertical root fracture. [14]

The removal of dentin chips during the time that the instrument is contacting dentin produces the canal shape. In studies using extracted teeth, dentinal damage and defects may be induced by some instrumentation methods. Although rotary instrumentation takes less time than instrumentation with hand files, hand filing has been reported to produce no dentinal cracks, crack initiation or propagation. [15]

Canal shaping is a critical stage for successful root canal treatment as it provides adequate space for effective disinfection and filling. It is achieved by instrumenting the dentin of root canal walls with endodontic files manufactured under different processes with different designs. However, this stage can also weaken the root structure by decreasing the root dentin thickness and producing stresses and strains especially in the apical region of the root. The weak root can easily fail by cracking. In addition, forces applied during canal shaping and canal filling can induce strain to a level that might cause cracks and vertical root fracture (VRF). The root surface strain (RSS) was increasing cumulatively during canal shaping with nickel titanium (NiTi) files, indicating that the root was expanding. Furthermore, momentary stress concentrations are created every time the file contacts the dentinal wall, mainly at a region near the file tip. [16]

Nickel-titanium (NiTi) endodontic instruments have been widely used in clinical endodontic treatment for providing better clinical prognosis and reducing postoperative symptoms and/or procedural errors. However, NiTi instruments sometimes fracture during usage without showing any signs of wear or distortion. Therefore, manufacturers have tried to develop brand new instruments with reduced fracture risk and better efficiency. Their trials involved changing the geometries, heat treatment methods, and kinematic movements of the instruments. [17]

Despite the advances made in root canal instrumentation, dentinal defects such as cracks have been observed after the use of an NiTi-based rotary or reciprocating system, which indicate the generation of deleterious root surface strain (SS) during canal preparation.[9]

The development of nickel–titanium (NiTi) rotary instruments is undoubtedly a quantum leap for the field of endodontics. Nevertheless, those who have gained some experience in the use of such instruments will confirm that each file system has its own special advantages and disadvantages and particular rules for its usage need to be followed. With most Ni Ti systems, it is easy to reach working length and prepare the apex to a small size such as International Standards Organization (ISO) size 20.[18]

Nickel-titanium rotary instrumentation systems are popular because of their apparent ease of use and reduced number of instruments. However, the strong emphasis on reducing the number of instruments and limiting apical preparations to small sizes does not produce clean apical preparations in diseased teeth. [19]

Over last two decades various Ni-Ti rotary instruments have been introduced to perform easier, faster and better root canal therapy. This system requires less time for root canal preparation than hand files but they will cause more frictions on canal walls due to increased number of rotations. This will result in micro cracks in root canal dentin.

In this study, we compared the rotary Mtwo files, K3XF files and hand K files in the dentinal defects induction.

AIM AND OBJECTIVE

AIM

The aim of present study is to compare the dentinal defects caused during root canal preparation with hand files and two different Ni-Ti rotary files systems.

OBJECTIVE

- To evaluate the file system causing minimal dentinal defects during root canal preparation.
- To evaluate and compare the different types of dentinal defects presenting in the root canal.

REVIEW OF LITERATURE

Lewinstein et al., (1981) [20] studied and determined the hardness of dentin taken from teeth that were extracted at different periods after root canal treatment. The results showed that the dentin hardness was not altered after endodontic treatment.

Anderson (1985) [21] in his study, the cutting ability on the "pull" stroke of square and rhombus cross-sectional endodontic files was measured and compared using a custom designed apparatus that controlled the force on the files and the length and number of strokes. The cutting efficiency was determined by measuring the depth of cut in poly (methyl methacrylate) wafers. The cutting efficiency was significantly increased in 30, 35, 40 size rhombus cross-sectional endodontic files whereas in sizes 20 and 25 there was no significant difference.

Yoshida et al .,(1995) **[22]** studied the effect of eliminating the smear layer by means of 15% EDTA solution as a root canal irrigant in 189 single-rooted infected teeth and suggested that 15% EDTA solution is more effective than saline solution as a root canal irrigant.

D'Souza et al., (1995) **[23]** compared the cross-sectional configuration, presence of cutting edges of seven files[Ground twisted (K-file, K-Reamer, and K-flex) and machined files (Flex-R, Unifile, S-file, and Hedstrom) #10, #25, and #40] at coronal and apical levels with diagrams presented by manufacturers. Files were embedded in acrylic, then cut [cross-section] in the apical and coronal parts of the flutes, were photographed under a microscope and six clinicians viewed the slides projected onto a screen. The inconsistencies were primarily in machined files, smaller sizes, and apical sections of the instruments.

Kazemi et al .,(1995) [24] evaluated the wear of seven different brands and types of files when machining human dentin. (Wafers of coronal dentin with a thickness of 1.5mm). It was shown that all files rapidly deteriorated when machining dentin. The highest relative efficiency after five sets was retained by the Maillefer K-file. It was suggested that endodontic files should be disposable.

Fadia et al.,(1995)[25] in their study, Flex-R, Ultra-Flex (Ni–Ti construction), and K-type files were compared using a circumferential filing technique on 96 extracted human maxillary molars. Buccal canals with minimal initial curvature of 24 degrees and maximal inital curvature of 52 degrees were used. The canal curvature was measured before and after filling, and changes were analyzed statistically. The angle of curvature was better maintained with the Flex-R and Ultra-Flex files.

Esposito et al.,(1995) [26] Maintaining the original canal path during instrumentation is a challenge in narrow curved canals. This study compared the maintenance of the original canal path of curved root canals during instrumentation with nickel-titanium (Mac) hand files, nickel-titanium engine-driven files, and stainless steel (K-Flex) files. Canal path maintenance was determined by superimposing instrumentation radiographs over an initial file radiograph and examining for discrepancies. Nickel-titanium hand and engine-driven instruments maintained the original canal path in all cases. The incidence of deviation from the original canal path during instrumentation with stainless steel files was increased with file size.

Tepel et al ., (1995) [27] investigated the cutting efficiency of 24 different types of endodontic hand instruments, which are primarily designed for a rotary (reaming) working action, were instrumented the resin specimens with simulated cylindrical canals . Stainless steel reamers and especially K files showed better cutting efficiency than Nitinol K-files.

Schafer et al., (1995) [28] investigated the shaping abilities of nickel-titanium K-files, stainless steel reamers,K-files, and flexible stainless steel instruments with conventional cutting tips and with modified non cutting tips were under standardized conditions using a computer-driven testing device simulating the clinical use of the instruments. Simulated root canals with a 42-degree curvature were sequentially enlarged from #15 to #35. Undesirable changes in the canal shape as a result of instrumentation occurred in all cases.

Kuhn et al (1997)., [29] evaluated the effect of modified and non-modified tip designs of both stainless steel and nickel-titanium endodontic hand files on root canal preparation. Root canals of mesial roots of extracted mandibular molars were prepared using a quarter-turn-pull technique, instrumentation to size 40 with step-back, the combination of modified tip and nickel-titanium alloy produced significantly more transportation and dentin removal, as well as greater deviation from the center at the mid-root level than other file designs.

Wilcox et al., **(1997)** [30] assessed the effect of lateral condensation forces on the development of vertical root fracture [VRF] in teeth that have undergone controlled, measured internal root reduction [i.e., canal preparation in 34 straight rooted maxillary anterior teeth].Twenty four hour after obturation ,the teeth were examined by transillumination for VRF, teeth not exhibiting VRF were tested further after gutta-percha removal and canal enlargement of 30%,40%,50%.Teeth were sectioned at 2mm and examined under stereomicroscope .No VRF at 20% or 30%. 5 teeth were fractured at 40% and 7 at 50% enlargement.

Bergmans et al., (2001) [14] described the unique shaft and tip designs should permit the use of a rotary handpiece allowing different tactile awareness. On the other hand, special attention is paid to maximize cutting efficiency and cutting control throughout instrumentation. It is important to consider that the preparation to a greater taper demands the removal of more dentin. Excessive deduction of hard tissues weakens the tooth structure and makes the roots more prone to fracture.

Helmut Walsch., (2004) [19] stated that coronally located canal curvatures, particularly when there is a considerable canal length located apically of the curvature, cannot be managed properly with tapered NiTi rotaries. NiTi hand files used in a step back approach or the use of Light Speed instruments seems to be the best option for such cases. Extremely severe curvatures should not be followed with any engine-driven instruments. NiTi K hand files with 0.02 taper or Light Speed instruments should be used, and only by hand.

Sathorn et al .,(2005) [31] determined whether rotary nickel-titanium (NiTi) canal preparation strengthens roots, and whether the fracture pattern can be predicted by finite element analysis (FEA) models. From a fracture mechanics viewpoint, structural defects, cracks or canal irregularities are likely to play a major role in fracture susceptibility of the roots, because stresses can be exponentially amplified at these sites.

Sathorn et al., **(2005)** [32] determined the extent to which canal size, radius of curvature and proximal root concavity influence fracture susceptibility and pattern. A standardized cross-section of the mid-root region of varying canal diameter, shape, and proximal concavity, these factors could be examined for roles in fracture susceptibility and pattern. The factors,all interact in influencing fracture susceptibility and pattern, with dentin thickness not the only determining factor. The removal of dentin does not always result in an increased fracture susceptibility, concluded that by maintaining the canal size as small as practical, a reduction in fracture susceptibility could be expected.

Peter et al .,(2007) [33] described hand instruments can create a smooth, open passage way for rotary instruments to follow as they progress to the apical terminus. Studies have demonstrated that manual root canal instrumentation with fine stainless steel hand instruments, used in a step-back manner before rotary instruments were used, significantly reduced the incidence of rotary instrument fracture during the preparation of curved canals.

Shemesh et al (2009) ., [34]in their ex vivo study evaluated the incidence of defects in root dentine before and after root canal preparation and filling. Eighty mandibular premolars were divided equally in four groups. Group 1 was left as unprepared and others were prepared by using Gates Glidden drills and System GT files up to size-40, 0.06 taper at the working length. Group 2 was not filled while the canals of the other groups were filled with gutta-percha and AH26, either with a master cone and passive insertion of secondary gutta percha points (group 3) or lateral compaction (group 4). Roots were then sectioned horizontally 3, 6, and 9 mm from the apex and observed under a microscope for the presence of dentinal defects. No defects were observed in the roots with unprepared canals. Canal preparation alone created significantly more defects than unprepared canals. The total number of defects after lateral compaction was significantly larger than after non compaction canal filling.

Souza Bier et al .,(2009) [35] compared the incidence of dentinal defects (fractures and craze lines) after canal preparation with different nickel-titanium rotary files. 260 mandibular premolars were grouped as unprepared (n -40) and prepared with manual Flexofiles (n - 20),with rotary files systems: ProTaper, ProFile, GT, S-ApeX (n - 50 each). Roots were sectioned 3, 6, and 9 mm from the apex and observed under a microscope for the presence of dentinal defects. No defects were found in the unprepared roots and those prepared with hand files and S-ApeX. ProTaper, ProFile, and GT preparations resulted in dentinal defects in 16%, 8%, and 4% of teeth, respectively.

Kim et al., **(2010)** [36] compared the stress conditions during rotary instrumentation in a curved root for three NiTi file designs. Stresses were calculated using finite element (FE) analysis. FE models of ProFile , ProTaper Universal and LightSpeed LSX were analysed. They suggested that file design affected apical stress & strain concentrations during instrumentation, which were linked to an increase in dentinal defects.

Asit Vats et al.,(2011) [37]evaluated the effect of two different root canal preparation techniques on inducing root fractures. Twenty four freshly extracted non-carious human mandibular incisors were randomly assigned to 3 groups of 8 teeth each. Group 1 control (unprepared) ,group 2 (prepared by hand instruments), group 3 (canal preparation done by both hand and rotary instruments). This study concluded that canal preparation techniques play a role in the causation of vertical root fractures.

Deog-GyuSeo and Young .,(2012) [38] analyzed the characteristics, distribution, and associated factors of longitudinal fractured teeth according to the well defined criteria of the American Association of Endodontists .107 teeth with longitudinal fracture from 103 patients were diagnosed and analyzed. The patients signs, symptoms, age, and sex were noted as well as the tooth number, dental arch, filling materials, size/classification of restoration, crack direction, pulp vitality, whether the patient had undergone endodontic treatment, bite test results, percussion test results, wear facet, and periodontal pocket depth. Out of 107 of longitudinal fractured teeth, 33 (30.8%) were treated endodontically and 74 (69.2%) were not. So vertical root fracture was associated with endodontic treatment.

Yoldas et al .,(2012) [39] compared dentinal microcrack formation while using hand files (HFs), 4 brands of nickel-titanium (NiTi) rotary files and the self-adjusting file. 140 mandibular first molars were selected: 20 teeth were unprepared (control) and the remaining 120 teeth were divided into 6 groups. HFs, HERO Shaper, Revo-S , Twisted File , ProTaper and Self Adjusting Files were used to prepare the 2 mesial canals. Roots were then sectioned 3, 6, and 9 mm from the apex, and the cut surface was observed under a stereomicroscope for the presence of dentinal microcracks. The control, HF, and SAF groups did not show any microcracks. In HS, RS, TF, and PT groups, dentinal microcracks were observed in 60%, 25%, 44%, and 30% of teeth, respectively.

Matsushita-Tokugawa et al.,(2013) [40] established the novel method Vibrothermography (VibroIR) to detect microcracks by the friction heat generated from ultrasonic vibrations. The root canals of 20 roots with cracks and control roots were prepared after removing the tooth crowns. A tapered indenter was inserted into the root canal and pressed until a microcrack was created under an optical microscope. Using VibroIR, the detection trials for dentinal micro cracks were performed. Frictional heat was detected in the micro cracks with thermography at 0.89 to 1.48W and at an ultrasonic vibration point angle less than 60 from the crack line for 10 seconds. Micro cracks with a width of 4 to 35.5 µm were detected with this method. This study concluded that the VibroIR may be an effective method for the diagnosis of root dentinal micro cracks.

Burklein et al., (2013) [41] evaluated the incidence of dentinal defects after root canal preparation with reciprocating instruments (Reciproc and Wave-One) and rotary instruments. Both rotary and reciprocating instruments resulted in dentinal defects. At the apical level of the canals, reciprocating files produced significantly more incomplete dentinal cracks than full-sequence rotary systems.

Lopes et al.,(2013) [42]compared the mechanical properties of endodontic instruments made of conventional nickel-titanium (NiTi) wire (K3 and Revo-S SU), M-Wire (ProFile Vortex), or NiTi alloy in R-phase (K3XF). The test instruments were subjected to mechanical tests to evaluate resistance to bending (flexibility), cyclic fatigue, and torsional load in clockwise rotation. The results showed that the K3XF instrument, which is made of NiTi alloy in R-phase, had the overall best performance in terms of flexibility, angular deflection at failure, and cyclic fatigue resistance. In addition to the alloy from which the instrument is manufactured, the design and dimensions are important determinants of the mechanical performance of endodontic instruments.

Elizabeth Ninan et al.,[2013] [43]investigated the torsion and bending properties of shape memory files (CM Wire, HyFlex CM, and Phoenix Flex) and compare them with conventional (ProFile ISO and K3) and MWire(GT Series X and ProFile Vortex) NiTi files. All were tested in torsion and bending per ISO 3630-1 guidelines by using a Torsiometer. They concluded that shape memory files show greater flexibility compared with several other NiTi rotary file brands.

Frank C. Setzer et al.,[2013] [44]determined the possible differences in the fracture point of rotary nickel-titanium instruments depending on the application of cyclic fatigue only (CO) or in combination with torsional stress. Three rotary Ni Ti systems were tested at 30^o under CO or CT (with an added 1-Ncm torsional load): Revo-S (Micro- Mega, Besancon, France), Vortex (Dentsply, York, PA), and Profile (Dentsply) of tip sizes 25 and 35. All fractures remained within the area of the curvature, but with the addition of a torsional load, the location of the fracture moved in the direction of the additionally applied torsional stress.

John T. McSpadden .,(2014) [45]described that the endodontic files basically have three functions: forming a dentinal chip, dislodging the chip, and transporting the chip from an area of file engagement to an area of file disengagement. Sharper more efficient files may have a rougher, scratchier feel than that of less efficient files. This is due to the formation of greater dentinal chips. These files require a lighter touch or less pressure for advancement to achieve the same results as less efficient files. Greater pressure can result in the formation a larger dentinal chips that can be easily removed and result in unnecessary excessive torsion stress.

Vamsee Krishna et al .,(2014) [46] compared and evaluated the incidence of dentinal damage during canal preparation with three different Ni-Ti Rotary systems (ProTaper Universal, Twisted files and Mtwo). 40 molar teeth were grouped control and k files (n-5) and rotary (n-10) and sectioned at 3mm, 6mm, and 9 mm from the apex and observed under Stereomicroscope. ProTaper Universal, Twisted files and Mtwo canal preparations showed 30%, 10% and 10% of dentinal defects respectively. No defects were found in the unprepared roots and those prepared with hand files. They concluded that irrespective of the rotary systems instruments with greater taper when used for root canal preparation could result in an increased chance for dentinal defects.

Hamed Saeed et al .,(2014) [47]evaluated and compared fracture resistance of teeth ,following canal preparation by hand instrument(k file) and rotary instrumentations (pro taper, Hero s file). 45 mandibular premolars teeth were divided into three groups of 15 teeth. The Control group was non instrumented, Group I -K-files (step-back technique). Groups II and III (crown-down technique) Hero s, ProTaper rotary files respectively. All roots were obturated with gutta-percha and AH26 sealer and were vertically loaded by using a universal testing machine. The Mean of fracture load was 520 Newton/mm^{2}for K-files, 345 Newton/mm^2 for pro taper files, 321 Newton/mm^{2}for Hero s files, the differences between rotary and hand groups were statistically significant but not significant between two groups of rotary instruments. This study concluded that the resistance to fracture was higher in hand instruments than rotary instruments.

Aminsobhani et al .,(2014) [48]evaluated the centering ability and remaining dentin thickness of two rotary nickel-titanium systems (Mtwo versus RaCe) and instrumentation techniques (conventional versus one rotary file) by cone-beam computed tomography. A total of 76 mandibular molar teeth were selected and divided into 4 groups (n = 19 teeth with 57 canals). The teeth were mounted in resin and pre-instrumentation scans were prepared by Cone Beam Computed Tomography (CBCT). The canals instrumented with Mtwo and RaCe rotary files either in conventional or one rotary file technique (ORF). After cleaning and shaping of distal and mesial canals, post instrumentation scans were performed by CBCT in the same position as pre instrumentation scans. Centering ability and remaining dentin thickness were evaluated by Planmeca Romexis viewer .Both of the instrumentation systems and techniques produced canal preparations with adequate centering ratio. One rotary file technique, prepared the canal significantly faster than conventional technique.

Yigit et al .,(2015) [49]evaluated the presence of dentinal defects after root canal preparation with hand instruments and two different reciprocating instruments. 60 mandibular incisor teeth were divided into three experimental groups(stainless steel hand instruments, Wave One Primary instruments and RECIPROC R25 instruments) and one control group (unprepared) (n -15). Horizontal sections were made 3, 6 and 9 mm from the apex and were stained with methylene blue and viewed through a stereomicroscope for the presence of dentinal defects(fractures, incomplete cracks and craze lines). No defects were observed in the unprepared group. All instruments caused dentinal defects, with no significant differences between the instrument systems and significantly more defects at the 3-mm level.

Garima Mohan .,(2015) [6]evaluated the effect of instrument design on inducing root fracture. 60 single rooted premolars were divided into 6 groups of 10 teeth and instrumentation was done by Crown-down technique.(stainless steel K hand files, stainless steel H hand files, Protaper NI-TI rotary files, Profile NI-TI rotary files, Hero-Shaper rotary files, RACE rotary files). Each specimen was sectioned horizontally at 3mm, 6mm and 9mm from the apex and were evaluated for the presence of fracture under stereomicroscope at 25 X magnification. Hand instrumentation with stainless steel K file causes least dentinal defects whereas NI-TI files can induce variable degree of dentinal damage during root canal preparation. Amongst NiTi rotary file, Protaper NiTi rotary files had shown the maximum incidence of root fracture whereas Profiles (Group-4) had shown the least incidence of root fracture.

Mavani et al., (2015) [50]evaluated and compared the incidence of root microcracks observed at apical root surface and within canal wall after canal preparations with different rotary and reciprocating files. Ninety single rooted teeth were divided into 6 groups of 15 each. Group 1 control (unprepared) . Teeth in Group 2, 3, 4, 5 and 6 were instrumented with ProTaper universal system, Mtwo, K3XF, ProTaper Next respectively in rotary motion and WaveOne system in reciprocating motion. All roots were sectioned perpendicular to the long axis at 2 and 4mm from the apex and observed under a stereomicroscope for the absence/presence of cracks. The ProTaper Next and WaveOne groups showed lesser incidence of cracks as compared to K3XF, Mtwo and ProTaper Universal groups This invitro study concluded that all of the instrumentation systems used in this study created microcracks in root dentin.

Vipin Arora et al.,(2015) [7] described the role of pericervical dentin (PCD) in the long term prognosis of the tooth .Root canal treatment leads to weakened tooth structure as a result of change in tooth internal structure, dehydration of pericervical dentin, strains in pericervical dentin due to excessive pressure during obturation and changes in the physical and mechanical properties of pericervical dentin. Rotary root canal instruments led to greater root canal enlargements and increased taper which leads to significant weakening of teeth due to excessive loss of pericervical dentin especially in the cervical region of the tooth which is more prone to fracture.

Ertugrul Karatas et al .,(2015) [13]compared the incidence of root cracks after root canal instrumentation with the TwistedFile TF Adaptive, WaveOne, ProTaper Next and ProTaper Universal systems in 75 mandibular central incisors.Then roots were horizontally sectioned 3, 6, and 9 mm from the apex and viewed through a stereomicroscope at 25X magnification for dentinal cracks. The control group had no cracks ,The Pro- Taper Next and TF Adaptive systems produced significantly less cracks than the ProTaper Universal and WaveOne systems in the apical section(3 mm).

Elizabeth Rose and Timothy.,(2015) [15]evaluated the dentinal cracks in nonextracted teeth after final instrumentation. 40 mandibular first and second premolars of pig jaws were divided into 5 groups (n = 8): (1) WaveOne 25/08; (2) ProTaper rotary S1, S2, F2 (25/08) ;(3) crown-down GT hand files 20/12, 20/10, 20/08; (4) positive control (purposefully cracked); and (5) negative control (uninstrumented teeth). After instrumentation, superficial soft tissue ,bone were removed carefully at the root apices and resected 1 mm coronal to the working length, stained with caries indicator dye, and transilluminated; images were viewed at 30X magnification for dentinal cracks. WaveOne, ProTaper rotary, and GT hand files produced no cracks. All positive controls had cracks; all negative controls had no cracks. So the presence of natural periodontal structures may prevent cracking or dentinal damage in teeth receiving orthograde root canal instrumentation.

Alireza Adl et al.,(2015) [51] evaluated the effect of using RC Prep during root canal preparation on the incidence of defects in root canal walls. 100 mandibular incisors with single canals were divided into (n = 20)1 control group (coronally flared with Gates Glidden drills with no further preparation) and 4 experimental groups were first coronally flared with Gates Glidden drills and then prepared similarly by means of ProTaper instruments. In group 2, irrigated with saline without RC Prep application; in group 3, teeth were irrigated with saline and RC Prep; in group 4, sodium hypochlorite (NaOCl) without RC Prep; and in group 5, both NaOCl and RC Prep. The apical root surface and horizontal sections 3, 6, and 9 mm from the apex were observed under a microscope for cracks. A significant difference was found between and among the 5 groups .Group 4 (NaOCl), which had the highest number of cracked teeth, was significantly different from group1. RC Prep, with both saline and NaOCl, had no significant effect on the incidence of microcrack. This study concluded that RC Prep was unable to reduce the risk of dentinal defects. NaOCl caused more defects when compared with saline.

Aktemur Türker S et al., (2015) [52]evaluated dentinal crack formation after root canal preparation with ProTaper Next system (PTN) with and without a glide path. Forty-five mesial roots of mandibular first molars were selected. Fifteen teeth were left unprepared and served as controls. The experimental groups consist of mesiobuccal and mesiolingual root canals of remaining 30 teeth, which were divided into 2 groups (n = 15): Group PG/PTN, glide path was created with ProGlider (PG) and then canals were shaped with PTN system; Group PTN, glide path was not prepared and canals were shaped with PTN system only. All roots were sectioned perpendicular to the long axis at 1, 2, 3, 4, 6, and 8 mm from the apex, and the sections were observed under a stereomicroscope for cracks . The incidence of cracks observed in PG/PTN and PTN groups was 17.8% and 28.9%, respectively. They concluded that the creation of a glide path with ProGlider before ProTaper Next rotary system did not influence dentinal crack formation in root canals.

Paleker et al .,(2016) [53] compared centering ability and apical canal transportation of K-files (KF), ProGlider (PG), and G-Files (GF) after glide path enlargement in curved canals by using micro– computed tomography at 3 levels: 1 mm (D1)and 7 mm (D7) from the apical foramen and at the point of maximum root curvature (Dmc). NiTi files cause less transportation than KF. At D1, KF was less centered than both NiTi files and PG remained more centered at Dmc and D7.

Jamleh et al .,(2016) [16]determined the effect of nickel titanium file design on the root surface strain generated and apical microcracks caused during canal shaping. 33 mandibular incisors were divided into LightSpeed X, FlexMaster and a control group. A strain gauge was fixed apically on the proximal root surface to determine the maximum strain during canal shaping. Except for the control group, all root canals were enlarged to size 50 and images were taken after removing the apical 1 and 2 mm of the root end and mean maximum strain values and presence of microcracks were noted . During canal shaping, the strain increased cumulatively with in LightSpeed X and FlexMaster. Both systems caused comparable microcracks. Although LightSpeed X produced higher maximum strain, no difference in microcrack development was found between both systems.

Liu et al .,(2016) [9]determined the root surface strain (SS) generated and the extent of canal center transportation during canal shaping using 3 different nickel-titanium instruments. Simulated root canals in resin blocks (n = 10 per group) were prepared using adaptive rotary motion with twisted files (Twisted File Adaptive [TFA];

reciprocating rotary motion with WaveOne(WO files) and continuous rotary motion with ProTaper Next files (PTN). Electrical strain gauges at 3 sites recorded SS real time during canal shaping, and the blocks were scanned by micro–computed tomographic imaging to assess the canal center deviation. An overall increase in root SS was observed after root canal instrumentation and mean maximum SS values induced during canal shaping strongly correlated with canal center transportation in the apical section and the coronal section.

Bruna Paloma et al.,(2017) [10]compared apical microcrack formation after root canal shaping by hand, rotary and reciprocating files at different working lengths using micro–computed tomographic analysis. Sixty mandibular incisors were randomly divided into 6 experimental groups (n = 10) ProTaper Universal for Hand Use, HyFlex CM, and Reciproc files working at the apical foramen (AF) and 1 mm short of the AF. The teeth were imaged with micro–computed tomographic scanning at an isotropic resolution of 14 mm before and after root canal preparation, and the cross-sectional images were assessed to detect microcracks in the apical portion of the roots. For all groups, the number of slices presenting microcracks after root canal preparation was the same as before canal preparation. Regardless of the working length, did not produce apical microcracks.

Dong-Min Choi and Jin-Woo Kim (2017) [17] in the ex vivo model,compared the vibration generated by several nickel-titanium (NiTi) file systems and transmitted to teeth under 2 different motions (continuous rotation motion and reciprocating motion).Sixty J-shaped resin blocks were trimmed to a root-shaped form and divided into 2 groups according to the types of electric motors: WaveOne motor and XSmart Plus motor Each group was further subdivided into 3 subgroups (n = 10 each) according to the designated file systems: ProTaper Next,ProTaper Universal and WaveOne systems. Vibration was measured during the pecking motion using an accelerometer attached to a predetermined consistent position. They concluded that the reciprocating NiTi file system may generate greater vibration than the continuous rotation NiTi file systems. The motor type also has a significant effect to amplify the vibrations.

Andreas Peters et al., (2017) [54]reviewed the current innovations in instrument design include modifications in helical angle, taper, and longitudinal shape as well as kinematics for prevention of threading in, less canal transportation, better canal wall preparation, and less fatigue accumulation. Nickel titanium alloy was trended towards the property martensitic [more flexible alloy modifications] by varying heat treatment, specifically after grinding, so that the martensitic finish temperature for recent instruments is often greater than room temperature. Testing methods for the assessment of canal transportation, cyclic fatigue, and corrosion were used for deriving information of new file systems.

ARMAMENTARIUM

ARMAMENTARIUM FOR THE SPECIMEN PREPARATIONS

1. Sixty extracted mandibular premolar teeth
2. Diagnostic radiographs
3. Face mask
4. Gloves
5. Plastic containers
6. Distilled water
7. Straight hand piece-(NSK, Japan)
8. Diamond disc (3M)
9. Ruler
10. PVC moulds
11. Dappen dish
12. Lecrans carver
13. Cold mould seal (DPI)
14. Self cure acrylic - RR Cold cure (DPI)
15. Glass slab
16. Stainless steel cement spatula
17. Poly vinyl siloxane elastomeric impression material -(GC , Exaflex)
18. DG 16 explorer(GDC)
19. Cotton plier (GDC)
20. Stainless steel bowls
21. Stainless steel trays
22. Cotton

23. Cotton holder
24. Gauze
25. 5% sodium hypochlorite –(Deor)
26. 17% EDTA gel-(Avueprep,Dent Avenue)
27. Normal saline-(Baxter)
28. Unolock 2ml syringes-(Hindustan Syringes Ltd.)
29. Endo block-(Dentsply, Maillefer,Switzerland)
30. Mani K file-(Mani inc,Japan)
31. M two endo file-(VDW, Munich, Germany)
32. K3XF endo file-(Sybronendo,Orange,CA)
33. X Smart endomotor with 16:1 gear reduction endo handpiece-(Dentsply,Maillefer,Switzerland)

FOR THE SECTIONING AND IMAGING OF SPECIMENS

34. Hard tissue microtome-(LEICA-SP-1600 ,Wetzlar, Germany)
35. Stereomicroscope 45X magnification (MSZ Bi ,Magnus)
36. Sony 16.1Mega pixel digital camera (Sony,Japan)

MATERIALS AND METHODS

Method of samples collection

Sixty human single rooted mandibular premolars, which were indicated for extraction due to poor periodontal prognosis and orthodontic reasons were collected from the Department of Oral and Maxillofacial Surgery, Vivekanandha Dental College for Women, Elayampalayam, Tiruchengode .

Infection control protocol for the teeth collected for this study

Collection, storage, sterilization and handling of extracted teeth were followed according to the Occupational Safety and Health Administration [OSHA] and Centre for Disease Control and Prevention recommendations and guidelines.

1. Handling of teeth was always done using gloves, mask and protective eyewear.
2. Teeth were cleaned of any visible blood and gross debris.
3. Distilled water was used in wide mouth plastic jars for initial collection.
4. Teeth were immersed in 10% formalin for seven days, following which the liquid was discarded and teeth were transferred into separate jars containing distilled water.
5. The initial collection jars, lids, and the gloves were discarded into biohazard waste receptacles.
6. As and when the teeth were required, they were removed from the jars with cotton pliers and rinsed in tap water.

Procedure

Teeth were immersed in 5% Sodium hypochlorite solution for ten minutes to remove all soft tissues. Calculus was mechanically removed from the root surfaces by ultrasonic scalers. Teeth were again stored in the fresh distilled water until the next procedure.

Radiographs [Fig:2&3] were taken from the bucco lingual and mesio distal projections to eliminate any teeth with double canal morphology, resorptions, and obstructions. Each specimen was examined with a stereomicroscope under 20X magnification [Magnus MSZ Bi] [Fig : 4-6] for excluding teeth with any external defects.

Inclusion criteria: Teeth with single root canal & intact apices were selected.

Exclusion criteria: Teeth with severe curvatures, apical resorptions, calcifications, and fractures were excluded.

Each specimen was decoronated by the diamond disc [3M] with water cooling to get a standard root length of 12mm [Fig: 10]. Each specimen was flattened in order to standardize the canal length, to ensure the straight line access and to provide a reference plane. Each specimen was coated with the poly vinyl siloxane elastomeric impression material (GC-Exaflex) and was embedded in the acrylic resin block which was made from self cure acrylic resin [DPI] [Fig: 12]. Then, the samples were stored in the distilled water until the next procedure. Then the specimens were randomly divided into four equal groups. Each group consist of 15 specimens [Fig:7].

GROUP 1	Control group	with unprepared canals	
GROUP 2	Hand file	K file (Mani inc, Japan)	Step back technique
GROUP 3	Rotary	Mtwo (VDW,Munich, Germany)	Crown down technique
GROUP 4	Rotary	K3XF (Sybronendo, Orange,CA)	Crown down technique

GROUP 1 [Control group]

Teeth in the control group were left unprepared and stored in the distilled water until the next procedure.

GROUP 2 [Hand K-files]

Each canal was instrumented with stainless steel K-files [Mani Inc,Tochigi-Ken,Japan] [Fig:16] by the step back method. Size 10-30 K-files were used for apical preparation and coronally increased upto size 70-80 K-files .Irrigation was done by using 5% Sodium hypochlorite solution (Deor) and 17% EDTA gel (Avueprep-Dental Avenue) was used as a lubricant. After instrumentation, canals were irrigated with normal saline. Finally canals were rinsed with distilled water. All specimens were stored in the distilled water until the next procedure.

GROUP 3 [Mtwo]

Each canal was instrumented with Mtwo Ni Ti files [VDW, Munich, Germany] [Fig:16] by the crown down method. Size 25.06 tapered file was used for shaping the coronal third followed by size 20.06 tapered file till the working length and size 25 .06 tapered file was again used for shaping apical third .

GROUP 4 [K3XF]

Each canal was instrumented with K3XF NiTi files [Sybron endo, Orange,CA] [Fig:17] by the crown down method. Size 25.08, 25.06 tapered files were used for shaping the coronal third followed by size 25.04 tapered file till the working length. Then size 25 .06 tapered file was used for shaping apical third.

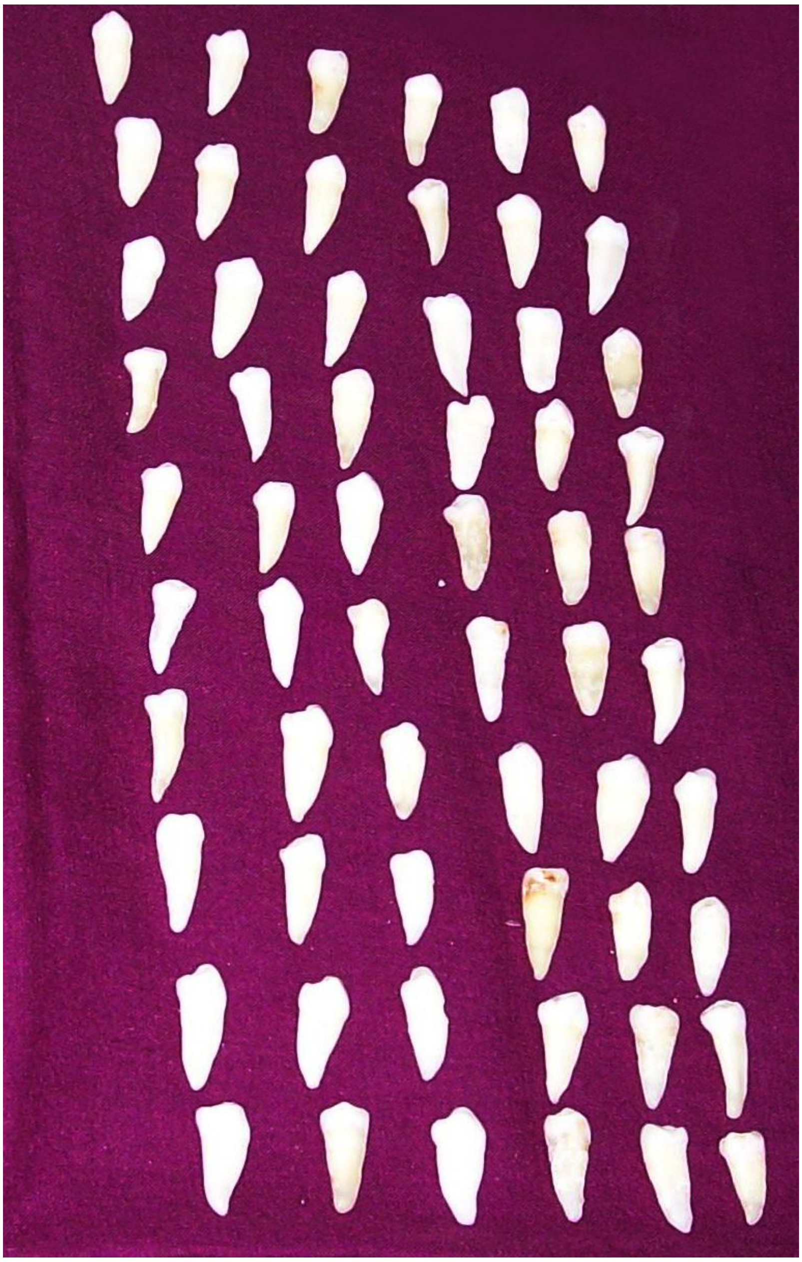
For **GROUP 3** and **GROUP 4**,root canal preparation done with the speed of 300 rpm and torque 0f 2Ncm by using the Torque and speed control electric X-SMART endomotor with 16:1 gear reduction handpiece [Dentsply ,Switzerland] [Fig:14]. Irrigation was done by using 5% Sodium hypochlorite solution (Deor) and 17% EDTA gel (Avueprep-Dental Avenue) was used as a lubricant. After instrumentation, canals were irrigated with normal saline. Finally canals were rinsed with distilled water using 2ml disposable syringe and a 26-G needle [Unolock, Hindustan syringes and medical device Ltd]. All specimens were stored in the distilled water until the next procedure.

Each specimen was sectioned horizontally at 3mm and 6 mm from the root apex by Hard tissue microtome under water cooling [LEICA SP-1600, Wetzlar, Germany] [Fig:18-19]. Then the sections were evaluated for the presence of dentinal defects under a stereomicroscope [Magnus] with 45X magnification. Then the photographs were taken with the digital camera [Sony,16.1 Mp] which was attached with the stereomicroscope The observations were categorised as the specimens with no defects and the specimens with dentinal defects at 3mm and 6mm levels. Based on the study of ***Wilcox et al [1997],***[30] dentinal defects again classified into

- **FRACTURE:** A line extending from the root canal surface to the outer surface of the root.
- **PARTIAL CRACKS:** Extending from the canal wall into dentin without reaching the outer surface of the root**.**
- **CRAZE LINE:** A line extending from the outer surface of the root into the dentin that cannot reach the canal lumen.

The data were collected and recorded for statistical analysis.

Fig 1: SIXTY EXTRACTED MANDIBULAR PREMOLAR TEETH



DIAGNOSTIC RADIOGRAPHS

Fig 2: BUCCO LINGUAL PROJECTION

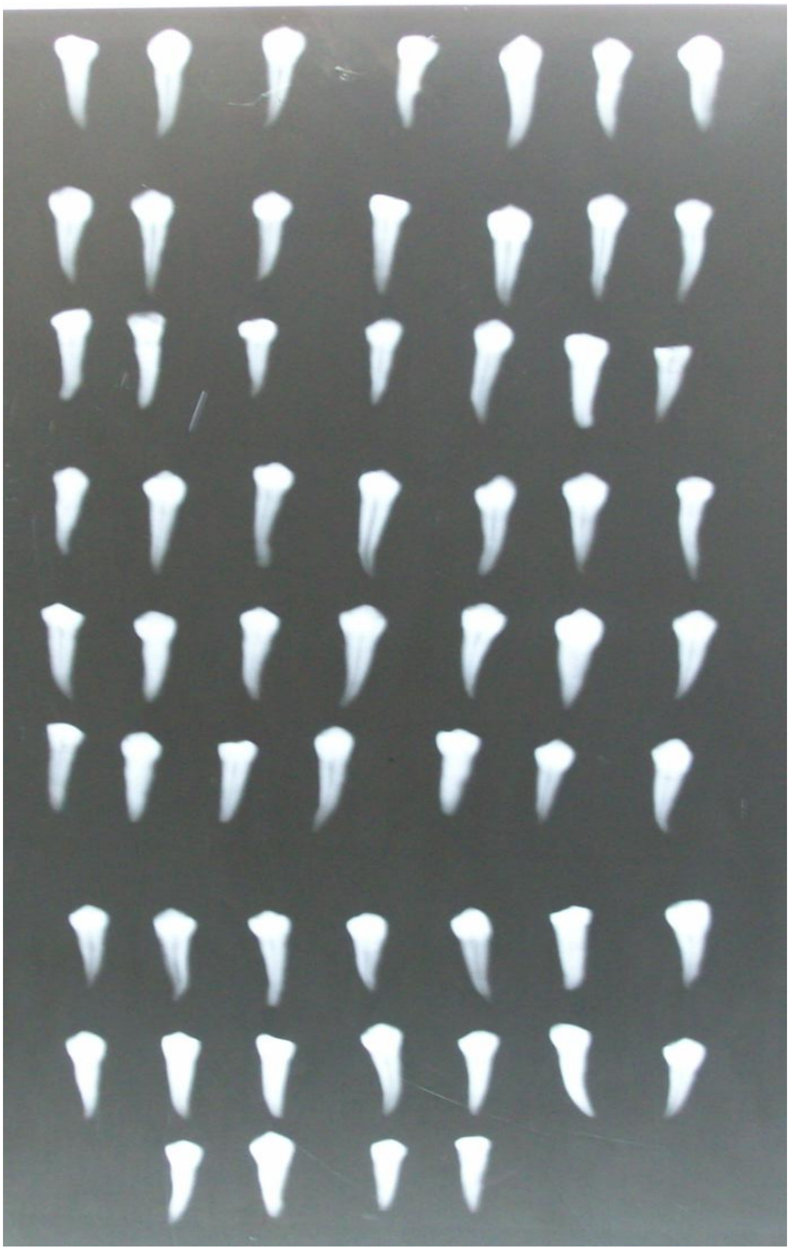


Fig 3: MESIO DISTAL PROJECTION

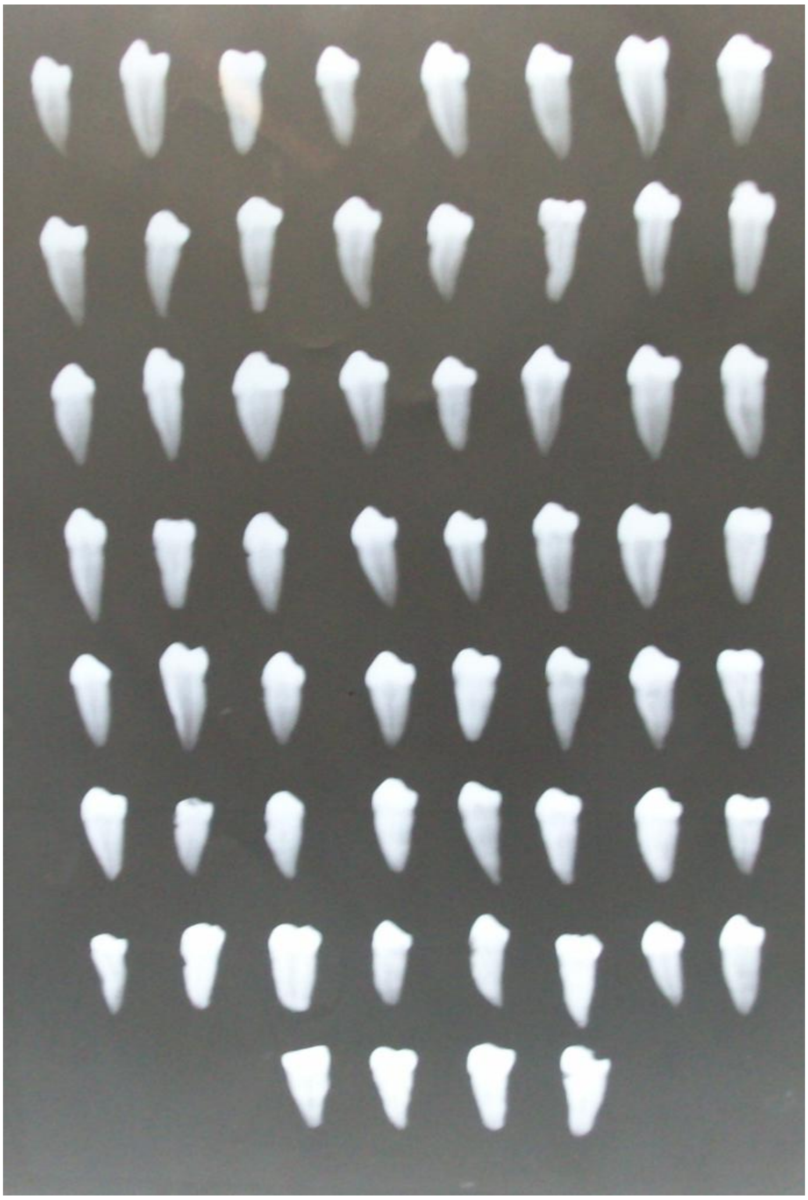


Fig 4: STEREOMICROSCOPE MAGNUS [45X MAGNIFICATION]

Fig 5: SPECIMENS OBSERVED FOR THE EXTERNAL DEFECTS

Fig 6: SPECIMENS OBSERVED UNDER STEREOMICROSCOPE

[20 X MAGNIFICATION]

Fig 7: SPECIMENS STORED IN THE DISTILLED WATER

Fig 8: MATERIALS FOR ACRYLIC MOULDS PREPARATION AND DECORONATION

Fig 9: SPECIMENS WITH MARKINGS FOR DECORONATION

Fig 10: DECORONATED SPECIMENS

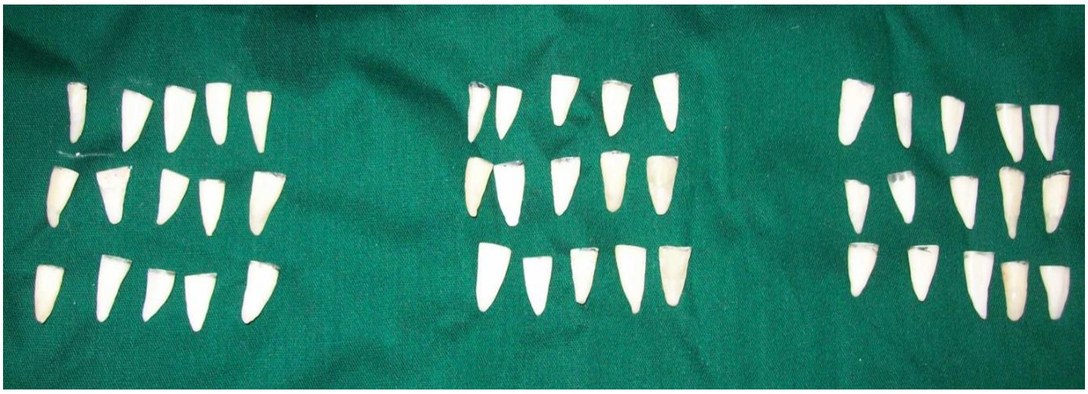


Fig 11: ACRYLIC RESIN MOULDS

Fig 12: POLY VINYL SILOXANE COATED SPECIMENS WITH IN ACRYLIC RESIN MOULDS

Fig 13: MATERIALS FOR ROOT CANAL PREPARATION [IRRIGATION]

Fig 14: MATERIALS FOR ROOT CANAL PREPARATION

Fig 15: HAND K FILES

Fig 16: ROTARY Mtwo FILES

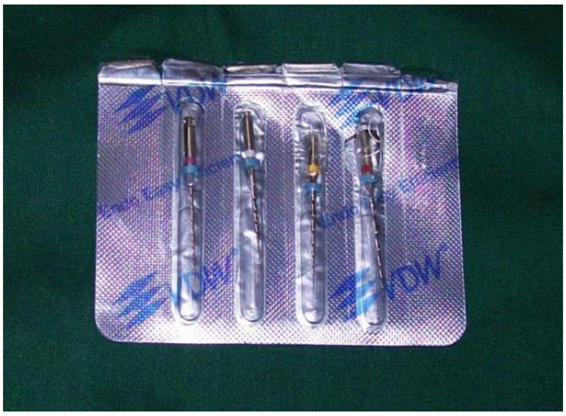


Fig 17: ROTARY K3XF FILES

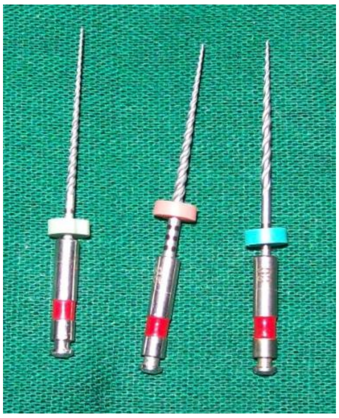


Fig 18: HARD TISSUE MICROTOME LEICA SP 1600

Fig 19: SECTIONING OF SPECIMENS WITH HARD TISSUE MICROTOME

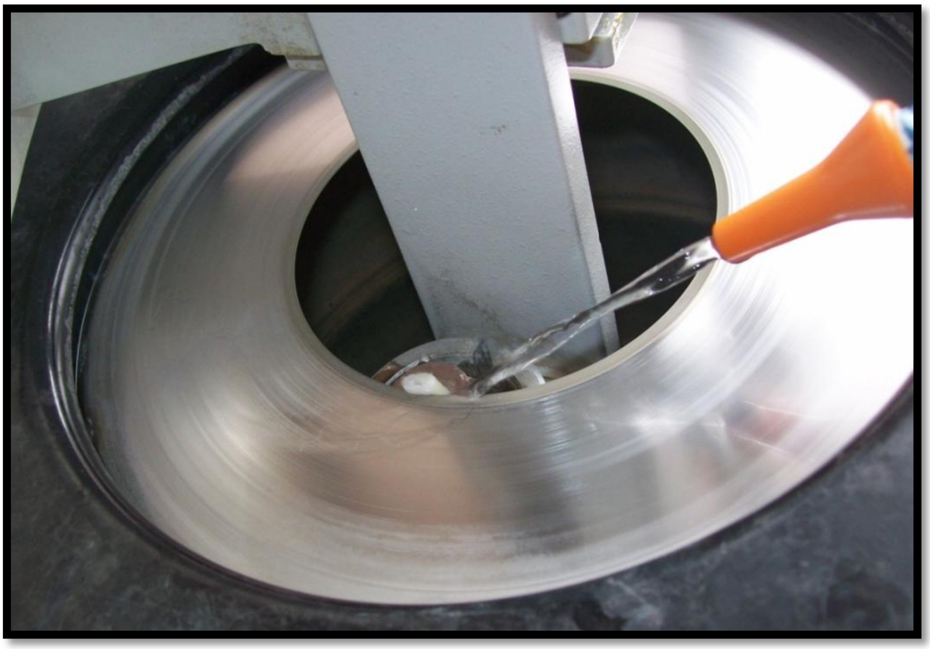


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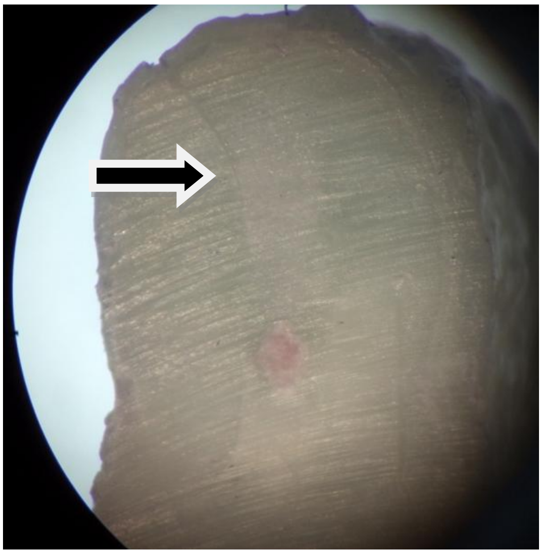
Fig 20: CONTAINERS WITH SECTIONINGS

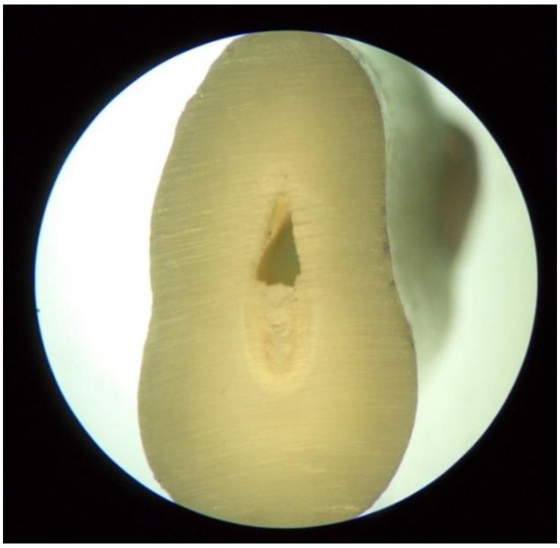
Fig 21: MOUNTED SPECIMENS AFTER SECTIONING

GROUP 1 [CONTROL]

CRAZE LINE

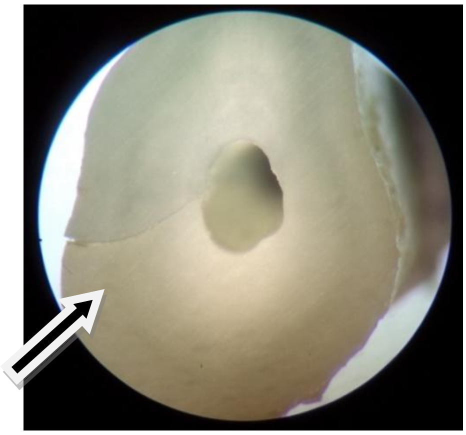


NO DEFECTS



GROUP 2 [K FILE]

FRACTURE



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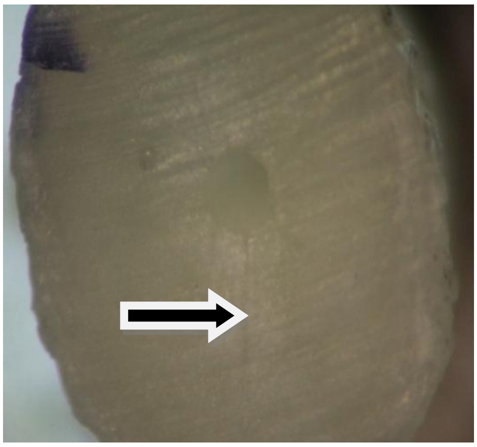
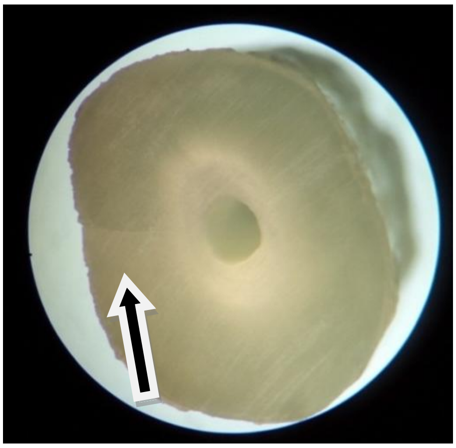
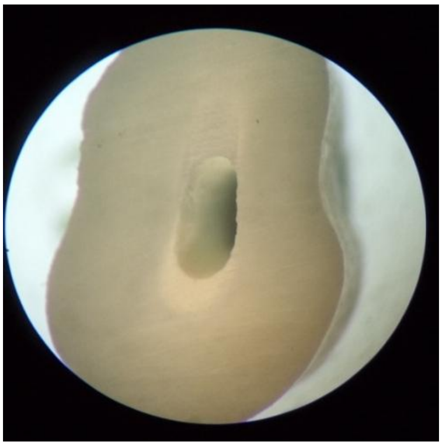


CRAZE LINE

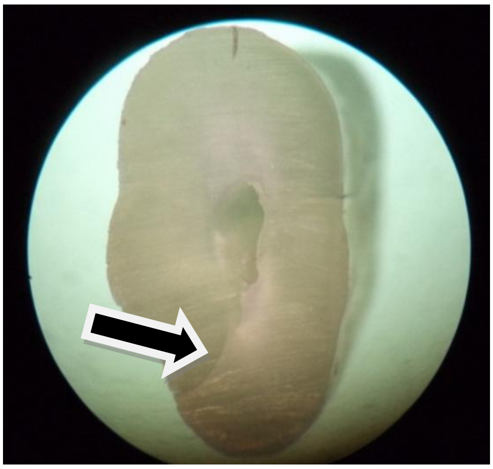


NO DEFECTS



GROUP 3 [Mtwo]

FRACTURE



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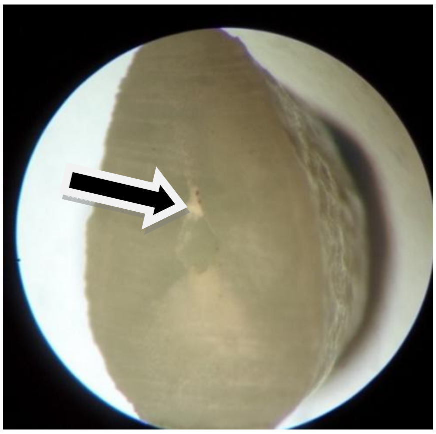
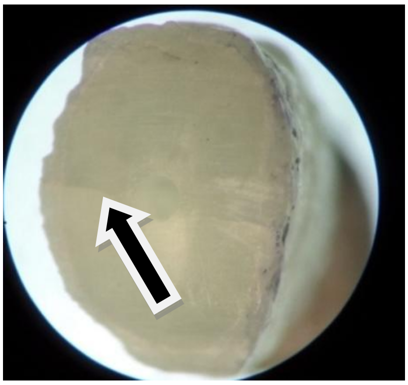
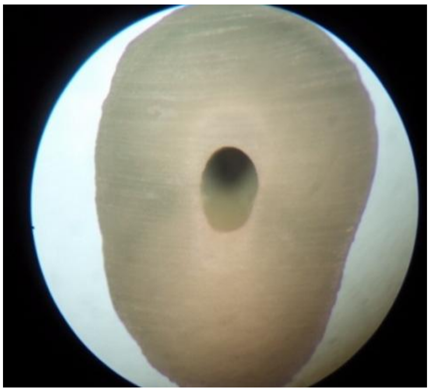


CRAZE LINE

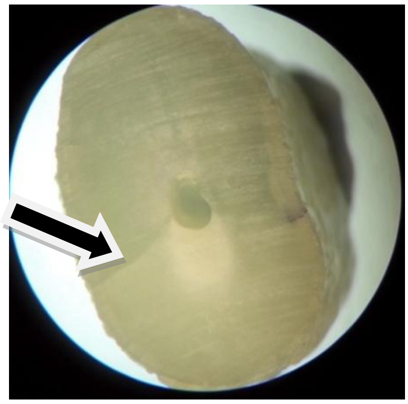


NO DEFECTS



GROUP 4 [K3XF]

FRACTURE



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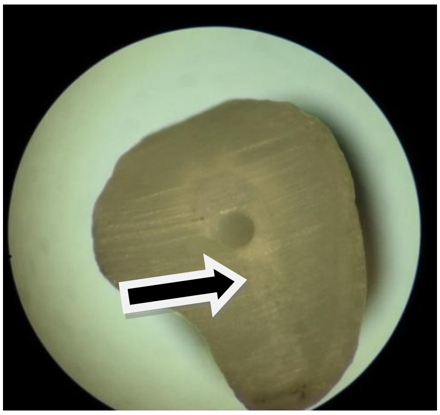
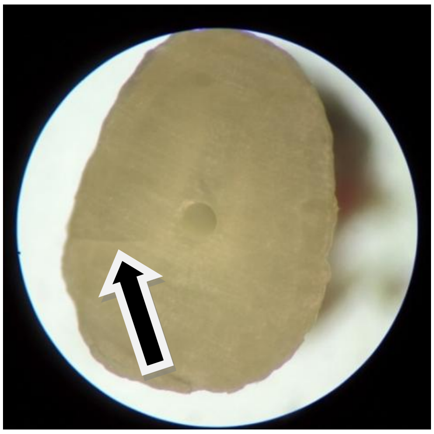
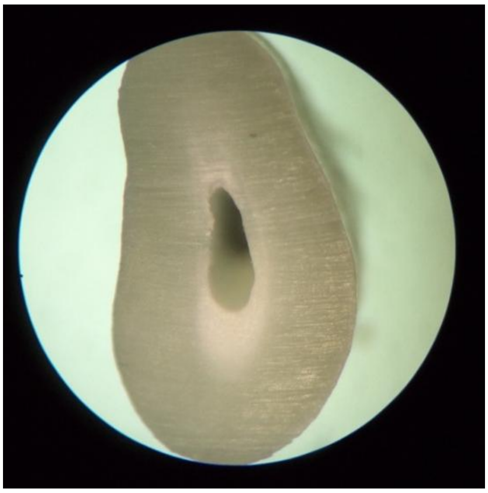


CRAZE LINE



NO DEFECTS



GROUP 1 [Control -Unprepared]

SPECIMEN NO	3mm	6mm
1	ND	ND
2	ND	ND
3	D [TYPE 3]	ND
4	ND	ND
5	ND	ND
6	ND	ND
7	ND	ND
8	ND	ND
9	ND	ND
10	ND	ND
11	ND	ND
12	ND	ND
13	ND	ND
14	ND	ND
15	ND	ND

ND- No defects

D- Defects

Type 1-Fracture

Type 2-Partial cracks

Type 3-Craze line

GROUP 2 [Hand K files]

SPECIMEN NO	3mm	6mm
1	ND	ND
2	ND	D[TYPE 3]
3	ND	D[TYPE 1]
4	ND	ND
5	ND	ND
6	ND	ND
7	ND	D[TYPE 3]
8	D[TYPE 3]	D[TYPE 3]
9	ND	ND
10	ND	ND
11	ND	ND
12	ND	ND
13	ND	ND
14	D[TYPE 2]	D[TYPE 3]
15	ND	ND

ND- No defects D- Defects

Type 1-Fracture

Type 2-Partial cracks

Type 3-Craze line

GROUP 3 [Mtwo rotary files]

SPECIMEN NO	3mm	6mm
1	D[TYPE 1]	D[TYPE 1]
2	ND	ND
3	ND	ND
4	ND	D[TYPE 2]
5	ND	ND
6	D[TYPE2]	ND
7	ND	ND
8	ND	ND
9	ND	ND
10	ND	ND
11	ND	ND
12	D[TYPE 3]	D[TYPE 1]
13	ND	D[TYPE 1]
14	ND	ND
15	ND	ND

ND -No defects D- Defects

Type 1-Fracture

Type 2-Partial cracks

Type 3-Craze line

GROUP 4 [K3XF rotary files]

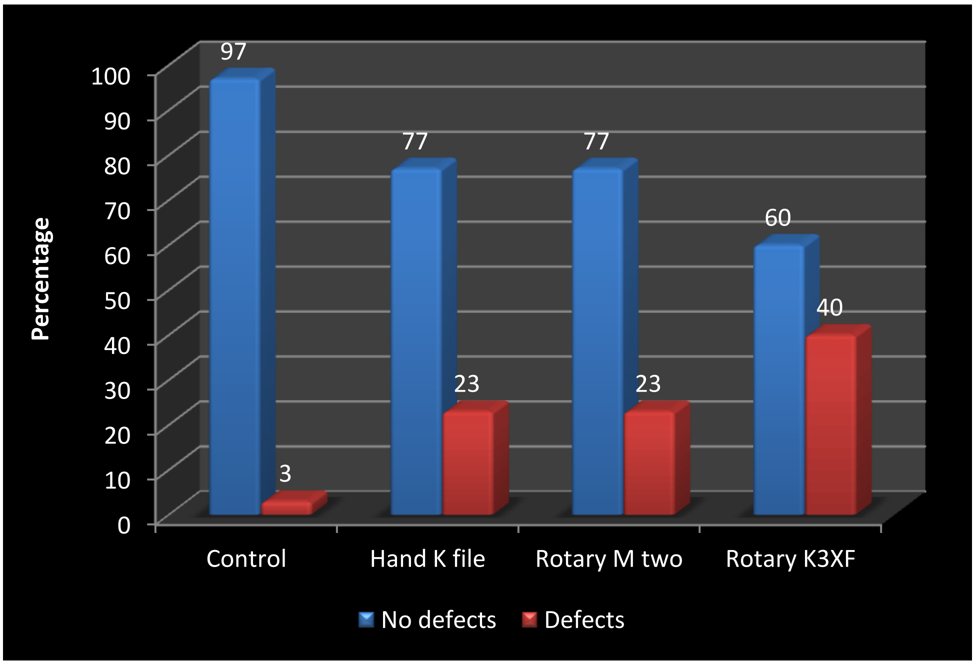
SPECIMEN NO	3mm	6mm
1	ND	ND
2	ND	ND
3	ND	ND
4	ND	D [TYPE 3]
5	ND	ND
6	ND	ND
7	D [TYPE 3]	D [TYPE 1]
8	D [TYPE 1]	D [TYPE 1]
9	ND	ND
10	ND	ND
11	ND	D [TYPE 1]
12	ND	ND
13	D [TYPE 2]	D [TYPE 1]
14	D [TYPE 2]	D [TYPE 2]
15	D [TYPE 3]	D [TYPE 1]

ND- No defects D- Defects

Type 1-Fracture

Type 2-Partial cracks

Type 3-Craze line

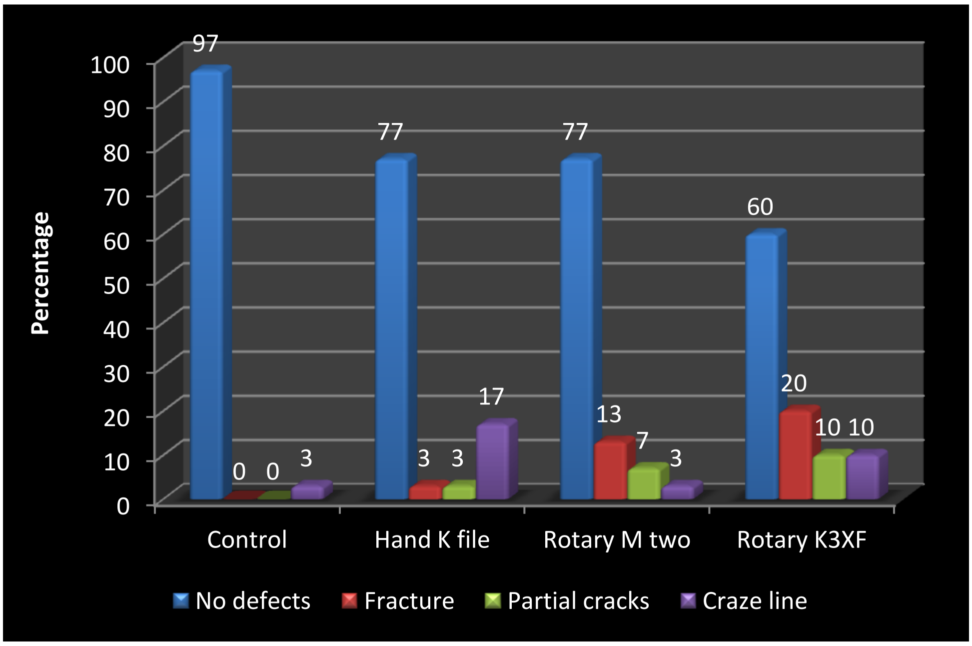


Graph 1: Percentage of No defects and Defects in each Group

Group	Defect				Total	Chi square	p
	No defects		Defects				
	N	%	N	%			
Control	29	97	1	3	30	11.61	0.009**
Hand K file	23	77	7	23	30		
Rotary M two	23	77	7	23	30		
Rotary K3XF	18	60	12	40	30		
Total	93	78	27	23	120		

* Significant at 5 %; ** Significant at 1 %; N-Number of specimens

Table 1: Comparison of No defects and Defects

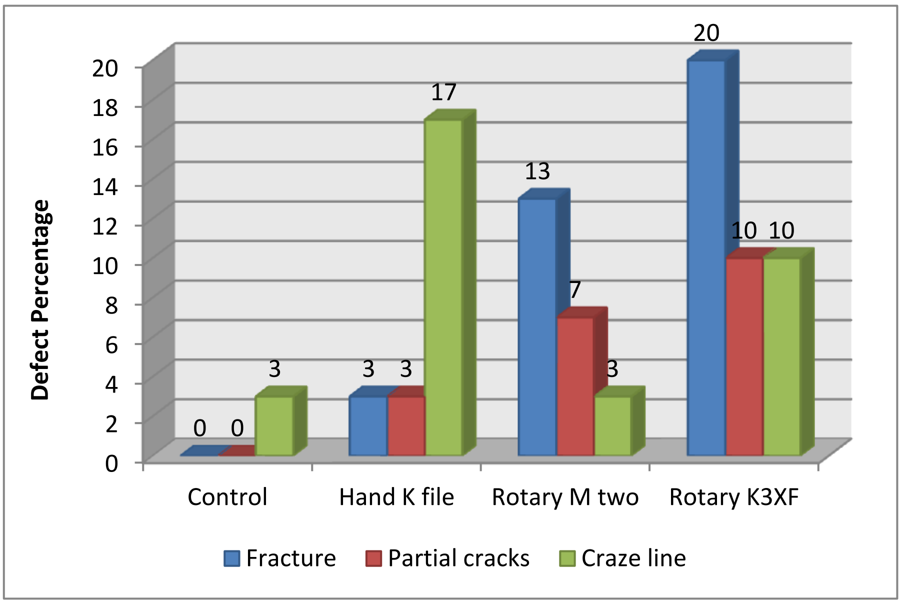


Graph 2: Comparison of No defects and Types of defects in each group

Group	Type								Total	Chi square	P
	No defects		Fracture		Partial cracks		Craze line				
	N	%	N	%	N	%	N	%			
Control	29	97					1	3	30	18.62	0.029*
Hand K file	23	77	1	3	1	3	5	17	30		
Rotary M two	23	77	4	13	2	7	1	3	30		
Rotary K3XF	18	60	6	20	3	10	3	10	30		
Total	93	78	11	9	6	5	10	8	120		

* Significant at 5 %; ** Significant at 1 %; N-Number of specimens

Table 2: Comparison of No defects and Types of Defects in between all groups

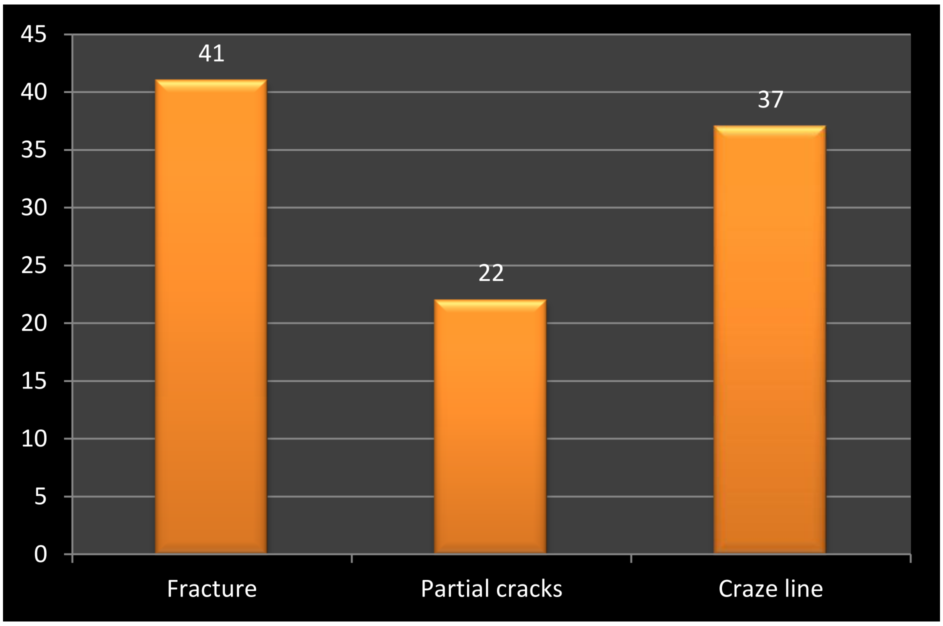


Graph 3: Comparison of Types of defects in each Group

	Type								Total	Chi square	P
	No defects		**Fracture**		**Partial cracks**		**Craze line**				
	N	%	N	%	N	%	N	%			
No defects	93	100							93	120.00	< 0.001**
Defects			11	41	6	22	10	37	27		
Total	93	78	11	9	6	5	10	8	120		

* Significant at 5 %; ** Significant at 1 %; N-Number of specimens

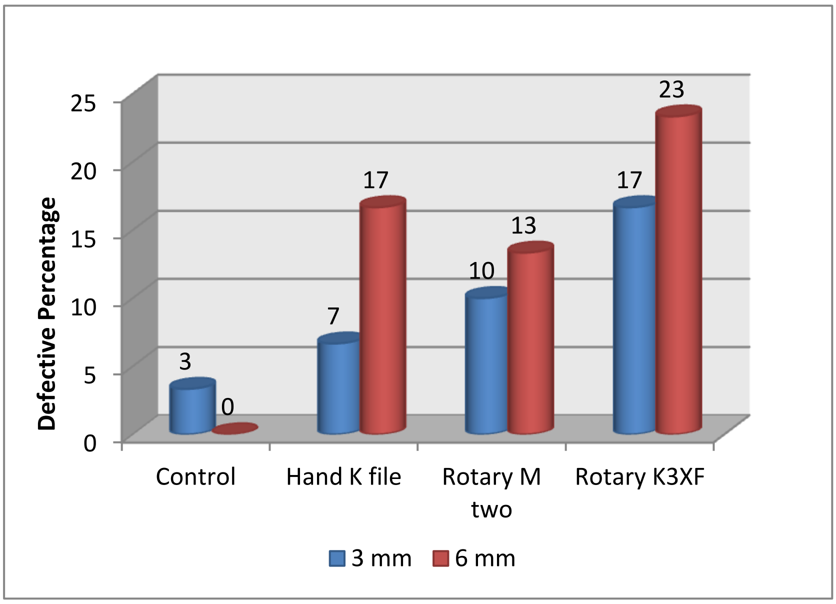
Table 3: Comparison of total percentage of No defects and Types of defects



Graph 4: Comparison of total percentage of Types of defects

	Frequency	**Percentage**
Fracture	11	41
Partial cracks	6	22
Craze line	10	37
Total	27	100

Table 4: Comparison of total percentage of Types of defects



Graph 5: Comparison of defects at 3mm and 6mm in between groups

Group	Defects				Chi square	p
	3 mm		6 mm			
	N	%	N	%		
Control	1	3			1.901	0.593
Hand K file	2	7	5	17		
Rotary M two	3	10	4	13		
Rotary K3XF	5	17	7	23		

N-Number of specimens

Table 5: Comparison of defects at 3mm and 6mm in between groups

RESULTS

The incidence of the different defects were analysed by using Chi Square test at a significance level of $p<0.05$.

The results were expressed as number and percentage of no defects and defects in each group.

- **Inter group comparison for defects**

Statistically significant difference [$p<0.05$] was observed when Group 2, Group 3, Group 4 were compared to Group 1.

- **Inter group comparison for types of defects**

When comparisons done for fracture, the results of this study showed the presence in the following order

Group 2 <Group 3<Group 4

When comparisons done for partial cracks, the results of this study showed the presence in the following order

Group 2 <Group 3<Group 4

When comparisons done for craze lines, the results of this study showed the presence in the following order

Group 1<Group 3 <Group 4<Group 2

- **Intra group comparison for types of defects**

Group 2 had more number of craze lines than fracture and partial cracks.

Group 3 had defects in the order of fracture > partial cracks > craze lines.

Group 4 had more number of fractures than partial cracks and craze lines.

When comparison done for **defects at 3mm and 6mm**, no statistical difference [p>0.05]was observed.

Finally,

When analysing the presence of defects in all Groups, the results of this study showed the presence of total defects in the following order.

Group 1< Group 2, Group 3 < Group 4

When analysing the presence of types of defects in all Groups,

Partial Cracks < Craze Lines <Fracture

DISCUSSION

The hallmark of successful root canal therapy is the removal of intracanal microorganisms, which are responsible for endodontic pathosis. This is accomplished through the implementation of specific instruments and irrigants that are used to debride shape and disinfect the root canal space within a tooth. Ideal instrumentation principles were described by Dr. Herbert Schilder who advocated that the preparation should result in a continuously tapering funnel from the coronal access to the root apex, maintain the original canal anatomy, keep the apical foramen in its original position with respect to the periapical tissues and the root surface, as well as keep the apical foramen as small as reasonably possible.

D.Ricucci(1998) [55], reviewed that all valid prognosis studies confirm the practice of staying short of the apex with a homogeneous obturation to obtain the highest success rate of 90-94%. **Weine (1982)** [55] stated that, in general, a point located 1 mm coronal to the apex is close to the area of the cemento-dentine junction (CDJ). He said that in the evaluation of the exact point where the canal preparation should end, 1 mm short of the radiographic apex is probably acceptable.

Vertical root fracture is suggested to be a result of gradual attenuation of root structure that may give rise to micro cracks and then fractures either during root canal treatment or by the effect of long-term occlusal stresses .Thus, understanding micro crack causes is of utmost importance for root canal treatment success. [16]

During root canal preparation, the canal is shaped via contact between the instrument and the dentinal walls, thus, creating a momentary stress concentration in the dentin. This stress concentration may lead to dentinal defects in which fractures can begin from. Higher incidence of dentinal defects was reported with nickel-titanium rotary files when compared to hand instruments. [36]

The goal of cleaning and shaping may be easily achieved with rotary files as far as relatively straight and narrow root canals with a round cross-section were concerned but in flat oval-shaped root canals and in curved ones, this goal was not easily attainable. When operated in flat root canals, rotary nickel-titanium files resulted in uneven thickness of the remaining dentin wall, a predisposing factor for vertical root fractures. Distal roots of lower molars, upper and lower bicuspids, and lower incisors and canines commonly have flat oval root canals. [56] In this present study , mandibular premolar teeth with single root canals were selected.

Studies of **Shemesh et al (2009), Souza Bier et al (2009), Asit Vats et al (2011), Yoldas et al (2012)** ,**Vamsee Krishna et al (2014)** ,**Hamed Saeed et al (2014)** [34,35,37,39,46,47] had intact teeth as control groups in order to determine if sectioning for observation induced cracks in their studies. In general, no cracks were observed in control groups, which lead authors to reject the hypothesis that sectioning was responsible for crack formation . In this study, control group specimens were kept unprepared.

During root canal preparation, contacts of instrument induce many momentary stress concentrations in root dentin wall that results in dentinal defects in which vertical root fracture can be initiated. [36] The smaller biomechanical preparation demonstrated lower stresses in comparison with the larger biomechanical preparation. Obturation process led to a significant increase in dentinal defects and a decrease of fracture resistance. In this present study , dentinal defects during root canal preparation were observed.

Adorno et al., [2009] [57] stated that the clinical situation is more complex because the presence of the periodontal ligament influences the distribution of forces. So the external reinforcement was avoided by using a thin layer of silicone as a simulated periodontal ligament .**Elizabath Rose and Timothy [2013], Ove Peters et al., [2004]** [15,2] were done studies with a layer of silicone to simulate the periodontal ligament. In this study poly vinyl siloxane elastomer was wrapped around the root surface to mimic the periodontal ligament.

Weine (1989) proposed that the apical enlargement must be three sizes larger than the first file that bound at the working length. To achieve a more accurate estimate of the apical diameter, removal of the interferences along the canal is necessary. After coronary thirds enlargement, the quality of the tactile sensitivity improves the estimate of the apical diameter .[58]

Glide path creation is essential for prevention of rotary file separation and most effective rotary use. Creating a 0.02 tapered glide path is critical for the safe and effective use of nickel-titanium rotary shaping instruments. Glide path can be further described as a manual glide path created with hand files, or a mechanical glide path created with rotary files. Routine glide path establishment and enlargement with glide path files can increase the lifespan of rotary instruments with a reduced risk of instrument fracture. [59]

Different techniques have been developed specifically for preparation of canals using ISO standardized 0.02 tapered stainless-steel hand files. Mullaney has described step-back technique which involves preparation of the apical region of the root canal first, followed by coronal flaring to facilitate obturation. [5]

In this present study, teeth were decoronated and root canal patency was established by No:10 K file in order to get accurate apical diameter and working length. For Group 2, Step back technique was used for root canal preparation.

Nickel–titanium (NiTi) was developed 40 years ago by Buehler. in the Naval Ordnance Laboratory (NOL) in Silver Springs, Maryland. Twisting, as it is done with stainless steel K files and K reamers, is impossible due to the superelastic properties and the memory effect of Nickel–titanium. Therefore, machining and grinding is the only way for NiTi.[60]

The development of nitinol, an equiatomic alloy composed of nickel and titanium, has proved to be a significant advancement in the manufacture of endodontic instruments. Nickel-titanium (NiTi) is called an exotic metal because it does not conform to the typical rules of metallurgy. NiTi alloy has special characteristics of super elasticity and shape memory. [60,61]

Zanesco et al., [2017][62] evaluated the apical transportation (AT), centering ratio (CR), and volume increase (VI) produced after instrumentation of mesiobuccal canals of maxillary molars with hand files, rotary, and reciprocating instruments using micro–computed tomographic (micro-CT) imaging and concluded that were similar for the K, ProtaperNext, and Reciproc groups.

Azar and Mokhtare (2011) [63]compared the cleaning ability and preparation time of rotary instruments (Mtwo) and conventional manual instruments (K-file) in preparing primary and permanent molar root canals. The Mtwo rotary system showed acceptable cleaning ability in both primary and permanent teeth, and achieved results similar to those of K-files in less time.

Kim et al., (2010) [36] suggested that file design affected apical stress & strain concentrations during instrumentation, which were linked to an increase in dentinal defects.

Yigit et al., (2015) [49] explained no defects were observed in the unprepared group. All instruments caused dentinal defects, with no significant differences between the instrument systems and significantly more defects at the 3-mm level. They concluded that the use of hand or reciprocating instruments could induce the formation of dentinal defects during root canal preparation.

The comparisons done between rotary Ni-Ti instruments and stainless steel hand instruments suggest that the manual technique with stainless steel instruments results in an equivalent cleaning ability or performs even better with significantly less debris. [64]

In this in vitro study, hand file group had less number of defects [23%] when compared to K3XF[40%] rotary NI-TI file group and equal number of defects to Mtwo group[23%]. When comparisons done for types of defects, percentage of teeth with fracture in hand file , Mtwo , K3XF groups [3%,13%,20%] respectively. Minimal tapering design, better tactile sense, manual control on removal of root dentin during preparation were the contributing factors for minimal defects. Minimal 2% tapering induce very less strain on root dentinal walls.

Mtwo

One of the most successful Ni-Ti rotary systems is Mtwo. The cross-section shape of Mtwo is an "italic S" with two cutting blades. The rake angle of Mtwo is one of the most effective measures in Ni-Ti rotary instruments, enhancing the cutting efficiency of this instrument. The tip is non-cutting, and the variable helical angle reduces the tendency of the instrument to be sucked down into the canal .[65]

Mtwo instruments have good cutting efficiency, low cross-sectional area and relatively low number of spirals in each length unit. Therefore, it can resist deformation, but it is more rigid too. This might explain the slightly higher incidence of canal aberrations observed in Mtwo system. The roots instrumented with the Mtwo were the least resistant, and the roots instrumented with the Protaper Next were the most resistant to vertical root fracture.[66]

Pontes et al., (2014) [67]described that the Mtwo instrumentation produced 41.48% of the uninstrumented perimeter. The final refinement using Hedstroem and ultrasonic files decreased the uninstrumented perimeter. Mtwo instrumentation was not capable of cleaning and shaping the entire perimeter of the root canals walls.

Vamsee Krishna et al., (2014) [46] compared and evaluated the incidence of dentinal damage during canal preparation with three different Ni-Ti Rotary systems (ProTaper Universal, Twisted files and Mtwo). They concluded that irrespective of the rotary systems, instruments with greater taper when used for root canal preparation could result in an increased chance for dentinal defects.

In this present study, Mtwo group showed less number of defects [23%] than K3XF group [40%] and same number of defects as in hand K file group [23%]. Mtwo group had 4 fracture type of defects where hand file group had one fracture.

K3XF

In 2011, K3XF was developed with the same R-phase heating and cooling protocol as Twisted File, but instead of being twisted, it was ground like K3 .The probability of a longer mean life was greater under reciprocating motion for all of the files (100% for K3, 87% for K3XF, and 99% for TF). Under continuous rotation, K3XF was more resistant than K3 and TF. [68]

Three brands of rotary instruments made from conventional NiTi alloy (BLX and OneShape) and R-phase heat-treated alloy (K3XF) were used, and all of them had different manufacturers recommended range of rotational speed. The ranges of One Shape, K3XF, and BLX are 300-350, 350-400, and 600 rpm, respectively. The results showed that the torsional resistances were not affected by changing the rotational speed of motor from 2 to 600 rpm. **Jung-Hong Ha et al.,[2016]** [69] in their study, the torsional resistances of the rotary instruments were not affected by the rotational speed. Different rotational speeds (eg: 2, 60, 350, and 600rpm) do not change the torsional resistance of nickel-titanium rotary files regardless of the alloy or heat treatment of the instruments.

K3XF exhibited different phase transformation behaviour and flexibility when compared with K3, which may be attributed to the special heat treatment history of K3XF instruments. The torque increased significantly with the diameter of K3XF and K3 instruments. **Shen et al., [2013]** [70] evaluated the bending and torsional properties of the thermomechanically treated K3XF NiTi instruments in relation to their phase transformation behavior. The bending load values were significantly lower for K3XF than for K3 in super superelastic ranges.

The manufacturer claims that K3XF provides clinicians with the basic features of the original K3 plus an extraordinary new level of flexibility and resistance to cyclic fatigue with the proprietary R-Phase technology. **Shen et al., [2015]** [71] concluded that the fatigue resistance of K3XF instruments was twice as high as that of K3 instruments. The torque and angle of rotation at fracture of K3XF instruments were similar to those of K3 instruments.

Lopes et al., [2013] [42] compared the mechanical properties of endodontic instruments made of conventional nickel-titanium (NiTi) wire (K3 and Revo-S SU), M-Wire (ProFile Vortex), or NiTi alloy in R-phase (K3XF). The results showed that the K3XF instrument, which is made of NiTi alloy in R-phase, had the overall best performance in terms of flexibility, angular deflection at failure, and cyclic fatigue resistance.

Olivierito [2014] [72]compared the K3 and K3XF systems (SybronEndo, Glendora, CA) after 1 and 2 uses by evaluating apical transportation, working length loss, and working time in a manikin model. K3 and R-phase K3XF rotary systems shaped curved root canals safely with minimal apical transportation, even up to a 40/04 file.

Sodium hypochlorite (NaOCl)

The use of sodium hypochlorite (NaOCl) solutions largely remains the mainstream approach for root canal disinfection because of the unique tissue proteolysis capacity and microbial suppression by NaOCl. Sodium hypochlorite (NaOCl) is used as a gold standard irrigating solution, which is used at different concentrations ranging from 0.5%–6%. [73] In this study, 5% Sodium hypochlorite (NaOCl) was used as an irrigating solution.

Brotzu, F. Felli [2013] [74] carried out the tests on the Perspex simulator, revealed no evident effects due to cyclic fatigue .The fatigue test showed a tendency to an increase of the operating life of the instruments when used with aqueous lubricant gel.

The depth of needle tip placement is an important factor in root canal irrigation. It has been recommended to place the needle tip to 2 mm short of the working length or slightly coronal to that point when resistance is encountered before the needle tip reaches the desirable length. [75]

Previous studies showed that any force applied inside the root canal during its shaping or obturation would strain the apical dentin circumferentially .In this study, we compared the dentinal defects at the apical region of the root canal.

With the hard tissue microtome, slices of very hard materials can be prepared without destroying the morphology of the specimens for the use in light microscopical investigation and section thicknesses of approximately 30 microns can be achieved under optimal conditions. In this study,[LEICA sp1600] hard tissue microtome was utilized for horizontal sectioning of specimens done at 3mm and 6mm from the root apex.

Beurklein et al.,[2013] [41] stated that craze lines in the unprepared teeth were, result of forces induced during extraction procedures. **Rajasekaran et al.,[2017]** [76]described the preexisting dentinal microcracks in roots of nonendodontically treated teeth .This micro-CT–based analysis of 633 teeth· showed a 7.1% prevalence of preexisting dentinal microcracks in roots .One crazeline was presented in the control group of this study.

Rotary instruments dominate the current scenario, the inexpensive conventional root canal hand files such as K-files and flexible files can be used to get optimum results when handled meticulously.

In addition to alloy from which the instrument manufactured, design, dimensions are important determinants for their performance in root canal preparation.

Attempts to reduce fracture susceptibility of the roots clinically are limited because many factors interact in influencing fracture susceptibility, and most of them are beyond the control of clinicians e.g. root shape, proximal concavity. The clinician can, however, reduce fracture susceptibility by maintaining the canal size as small as practical, and by working for a smooth round canal without irregularities.

SUMMARY

The purpose of this in vitro study was to evaluate and compare the dentinal defects caused during root canal preparation done by **hand K files, rotary Mtwo and K3XF files**.

The study samples comprised of sixty extracted intact, non carious human mandibular premolars. All selected teeth were decoronated and standardized to root length of 12mm, then randomly divided into 4 Groups. Each Group consist of 15 specimens.

Group 1: Control Group with unprepared root canal.

Group 2: Root canal preparation done by hand K files. [Step back method]

Group 3: Root canal preparation done by rotary Mtwo files. [Crown down method]

Group 4: Root canal preparation done by rotary K3XF files. [Crown down method]

During root canal preparation of all specimens ,5% sodium hypochlorite was used as an irrigating solution and 17% EDTA gel was used as a lubricant and final rinsing done with normal saline then with distilled water .All specimens were stored in the distilled water until further sectioning procedures.

Horizontal sectioning were done with hard tissue microtome under water cooling at 3mm and 6mm levels from the root apex Each section was evaluated for dentinal defects under the Stereomicroscope of 45X magnification.

The dentinal defects were presented in the order of

Group 1 < Group 2 , 3, 4

Group 2= Group 3

Group 3 < Group 4

Types of dentinal defects were presented in the order of

Group 2: Craze lines > Fracture and Partial cracks.

Group 3: Fracture > Partial cracks > Craze lines.

Group 4: Fracture > Partial cracks and Craze lines.

CONCLUSION

Within the limitations of this in vitro study, the following conclusions were made

- **Hand K files** induced minimal dentinal defects.
- **Hand K files** and **rotary Mtwo files** induced minimal dentinal defects when compared to **rotary K3XF files**.
- **Rotary K3XF files** induced more dentinal defects than all other Groups.
- **Rotary Mtwo files** induced more number of fracture type of defects when compared to **hand K files**.
- Rotary **Mtwo files** induced less number of fracture type of defects when compared to Rotary **K3XF files**.
- Fracture type of defects occurred more predominantly in all rotary files when compared to **hand K files**.

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INSTITUTIONAL ETHICS COMMITTEE
VIVEKANANDHA DENTAL COLLEGE FOR WOMEN

SPONSORED BY : ANGAMMAL EDUCATIONAL TRUST

Ethics Committee Registration No. ECR/784/Inv/TN/2015 issued under Rule 122 DD of the Drugs & Cometics Rule 1945.

No: VDCW/IEC/10/2015

Date: 14.12.2015

TO WHOMSOEVER IT MAY CONCERN

Principal Investigator: Dr. Karthi Priya .G

Title: An in vitro study to compare the Dentinal defects caused during Root canal preparation with hand file and two diffferent Ni Ti Rotary File systems.

Institutional ethics committee thank you for your submission for approval of above proposal. It has been taken for discussion in the meeting held on 04 .12.15.The committee approves the project and it has no objection on the study being carried out in Vivekanandha Dental College For Women.

You are requested to submit the final report on completion of project. Any case of adverse reaction should be informed to the institutional ethics committee and action will be taken thereafter.

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