CBCT EVALUATION OF DEEPEST PORTION OF FURCAL GROOVE IN MAXILLARY FIRST PREMOLARS BEFORE AND AFTER INSTRUMENTATION WITH STAINLESS STEEL HAND FILES AND TWO NITI ROTARY FILE SYSTEMS.

Dissertation submitted to

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DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation titled **"CBCT EVALUATION OF DEEPEST PORTION OF FURCAL GROOVE IN MAXILLARY FIRST PREMOLARS BEFORE AND AFTER INSTRUMENTATION WITH STAINLESS STEEL HAND FILES AND TWO NITI ROTARY FILE SYSTEMS"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. R. ANILKUMAR M.D.S,** Professor and HOD, Department of Conservative Dentistry and Endodontics, Ragas Dental College and Hospital, Chennai.

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This dissertation is submitted to **THE TAMILNADU Dr.M.G.R.MEDICAL UNIVERSITY**, in partial fulfillment for the degree of **MASTER OF DENTAL SURGERY – CONSERVATIVE DENTISTRY AND ENDODONTICS, BRANCH IV**. It has not been submitted (partial or full) for the award of any other degree or diploma.

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S.NO	ABBREVIATIONS	DESCRIPTION
1	BMFP	Bifurcated maxillary first premolar
2	RDT	Remaining residual dentin thickness
3	DCW	Dentine cementum wall
4	SS	Stainless steel
5	NF	Neoendoflex file
6	WO	WaveOne
7	NiTi	Nickel titanium
8	CBCT	Cone Beam Computed Tomography
9	µCT	Micro-computed tomography
10	3D	Three dimensional

Introduction

INTRODUCTION

The primary objective of endodontic therapy is to create a biologically acceptable environment within the root canal system which allows the healing and continued maintenance of healthy peri-radicular tissue. This objective can be achieved by eliminating the bacteria(source of infection) from within the root canal system, and sealing the entire root canal system to prevent re-infection. Bacterial infection of the root canal is the prime cause of apical periodontitis[8]. One of the most important steps in root canal treatment is cleaning and shaping. Cleaning is necessary to remove all pulp tissues, necrotic debris, microorganisms and the infected layer of dentin from the canal walls, whilst shaping involves the enlargement of the canal system to facilitate the cleaning procedure[1].

Traditionally chemo mechanical preparation of the root canal is done through a combination of mechanical instrumentation and antibacterial irrigants to eradicate microorganism in root canal system. Study by Bystrom and Sundqvist reported a 100–1000fold reduction in bacterial load after instrumentation with stainless steel hand files and normal irrigation with physiological saline[8] . The use of irrigating solutions with strong antimicrobial activity is an essential adjunct to mechanical preparation in order to further reduce bacterial numbers. In addition, the use of an antibacterial intracanal dressing has been advocated to eliminate bacteria remaining after chemo mechanical preparation which is followed by hermetic seal of the root canal space. This is to ensure seal of potential avenues of re-entry of micro-organisms into the root canal, and to entomb remaining microorganisms if any to prevent their proliferation.

Shaping and cleaning mostly emphasis on preparing evenly tapered root canals. Schilder had suggested a continuously tapering funnel from coronal access cavity to the root apex while root canal preparation[63]. This was to ensure efficient delivery of antimicrobial irrigants and thereby flushing out debris from the root canal. As more emphasis was given to achieve this taper or conical preparation more amount of radicular dentin was removed and a wider canal preparation was done which eventually weakened the root structure.

Different techniques havebeen developed specifically for preparation of canals using ISO standardized 0.02 tapered stainless-steel hand files. Basic cleaning and shaping strategies for root canal preparation can be considered as apico coronal preparation and corono apical preparation. Mullaney proposed step-back technique which involved preparation of the apical region of the root canal first, followed by coronal flaring to facilitate obturation. Due to the inherent flexibility of files (except the smaller size files) this technique often results in iatrogenic damage to the natural shape of the canal when employed in curved canals[63]. Thus to overcome and to reduce the errors crown-down techniques were developed which starts preparation by using larger instruments at the canal orifice and then work down the root canal with progressively smaller files. Pre-enlarging the coronal region of the canal prior to completing apical preparation provides several advantages, including straighter access to the apical region, as well as minimize or eliminate the amount of necrotic debris that could be extruded through apical foramen during instrumentation, improved irrigant penetration and enhanced tactile control. Studies have shown that step-down techniques produce fewer canal blockages, less apically extruded debris, and a reduced incidence of apical transportation when compared to step-back techniques. Abou Rass, Glick and Frank described a method called anticurvature filing to prevent excessive removal of dentin from thinner root section in curved canals. The technique includes use of precurved hand files that were purposefully manipulated to file the canal away from the danger zone (furcation side). These anticurvature filing reduced the risk of perforation.

Lim and Stock found that anticurvature filing preserved a greater thickness of the furcal wall than the step back method and reduced the risk of perforation. However different instrumentation techniques have been reported to affect the amount of radicular dentin differently in the perforation prone areas of the root. McCann compared the degree of encroachment upon the furcation area in mesial roots of mandibular molars during hand or ultrasonic instrumentation and found that both techniques came dangerously close to creating stripping and perforations in a high percentage of cases[32].

The introduction of nickel titanium in endodontics has permitted the development of NiTi rotary instruments which are considerably more resistant to torsional stress and are capable of safely preparing curved canals with less straightening compared with stainless steel instruments[3]. Accordingly, traditional instrumentation techniques such as the step-back method are now phasing out because of the increasing and expanding use of NiTi instruments. It must be realized, however, that because of their extreme flexibility, NiTi instruments are not designed for initial negotiation of the root canal, or for bypassing ledges. Because of their greater stiffness, small stainless steel instruments should be used for path-finding and to establish canal patency. Creation and subsequent maintenance of a smooth glide-path from the canal orifice to the apical foramen using fine 0.02 tapered hand files is an essential preparatory step before commencing NiTi instrumentation in order to reduce the risk of iatrogenic errors such as ledge formation and instrument fracture.

Structural integrity of the root canal system is impaired by the size and taper of the rotary instruments used to shape the canal. Remaining residual Dentin Thickness (RDT) is considered a critical factor following canal preparation for both prosthetic restoration and long-term prognosis of a tooth. A compromise in the remaining RDT may predispose the tooth to lateral or strip perforations or root fracture. Lim and Stock attempted to establish a minimal RDT required for sustainment of root integrity during lateral condensation[18]. They speculatively set 0.3 mm as the minimal remaining RDT at which condensation forces may exceed the resistance of the dentin and thus lead to perforation or fracture. Their study did not account for the cementum layer present on roots and assumed the proposed 0.3 mm minimum was dentin alone.

McCann et al suggested that histologically RDT is composed of both the remaining dentin and intact cementum layers and should be referred to as Dentin-Cementum Wall (DCW) thickness[37]. They speculatively set 0.5 mm as the minimum DCW thickness required toprevent strip perforation or weakening of the mesial root in mandibular first molars following instrumentation.

The bifurcated maxillary first premolar (BMFP) often presents with unique anatomicalfeatures that require consideration during endodontic therapy. The prevalence of bifurcation has been found to be 61% of maxillary first premolars. According to Pucci and Reig, 54.6% of maxillary first premolars have two roots; and, according to Black, 60% of maxillary first premolars have two roots[51]. BMFP has been extensively studied for thepresence of a developmental groove on the lingual surface of the buccal root. The groove was previously reported as a “developmental depression”, a “buccal furcation groove”, or a “furcal concavity”. Though, the prevalence of this external anatomic feature is very high, ranging from 62% to 100%, few morphometric (form and shape) studies have been conducted to describe its characteristics [52].

Tamse et al were the first to conduct a morphometric study on the buccal furcation groove in a sample of freshly extracted BMFPs[51]. They described the groove as starting justapical to the bifurcation, reaching a mean maximal depth of 0.4 mm at a mean distance of 1.18mm from the bifurcation, becoming gradually shallower, travelling to a mean distance of 5.38mm and disappearing towards the apex. The mean thickness of palatal dentin at the level of deepest invagination of the groove was found to be 0.81 mm. They noted that in the vertical plane, a negative co-relation exists between the distance of the bifurcation from the top of the buccal cusp and the distance of the deepest invagination from the bifurcation. This implies that, as the bifurcation is located more coronally, the deepest invagination is more remote from the bifurcation and vice-versa. Tamse et al concluded that the furcation groove of the buccal root of BMFP necessitates the reappraisal of the quantity of dentin removed during endodontic preparation or the application of posts in the buccal root for tooth restoration[52].

Lammertyn et al assessed 141 BMFPs to accomplish an anatomic study of furcationgrooves and dentin width in buccal roots[34]. They found that 83% of studied teeth had furcalgrooves in the buccal root; the mean depth of this groove was 0.05mm in the apical third,0.34mm in the middle third, and 0.36mm in the coronal third. Different authors have found themean thickness of palatal dentin to be 1.18mm, 1.31mm and 0.99mm.

Periapical radiographs are considered standard of care in endodontic treatment. Two-dimensional radiographs are of significant value to the clinician but are of limited use when determining location of various anatomical features[59] . Three-dimensional (3D) radiographic images are potentially of immense benefit in assessing anatomical structures and treatment planning. 3D image representation of changes in DCW thickness before and after instrumentation has been previously studied. It is in this aspect that the use of Cone Beam Computed Tomography (CBCT) has gained momentum in endodontics. The CBCT provides an invasive evaluation method for both the external and internal morphology of a tooth[35]. A characteristic of CBCT is its ability to measure both initial and post-instrumentation DCW thickness. This unique feature is important because it provides a reliable control (initial RDT) against which, each successively instrumented canal can be compared and analyzed. Subsequent scans can be produced following canal preparation providing an excellent way to examine the root canal in a non-destructive manner. It affords a virtual *in situ* image. Likewise, physical cross sectioning of the root is avoided which can invariably result in a loss of 0.4 mm or greater in each horizontal cut subsequently, the loss of tooth structure may affect the accuracy of post-instrumentation data[52]. Kobayashi et al evaluated the accuracy of measurement of distance on the images produced by limited CBCT[33]. Their data indicated that limited CBCT can beused to measure distance between points more accurately than Spiral Computerized Tomography. For the purpose of this study, a CS 9300 limited field CBCT machine was utilized.

To date no study has compared the performance of different rotary systems in terms of removal of dentin from the buccal root of BMFPs. Zigo et al studied the DCW thickness along the furcation groove in BMFPs after preparation with three successively larger, 0.04 tapered, nickel titanium rotary files using CBCT[62] . They concluded that instrumentation of the midgroovein

BMFPs reduces the DCW thickness to levels that may be insufficient to ensure tooth integrity.

Recently, the WaveOne (WO) NiTi file system has been introduced to the marketplace[46]. In this system a single NiTi (M-Wire technology) file is used in a reciprocating headpiece to completely prepare the canal to an adequate size and taper, even in narrow and curved canals. The specially designed NiTi files work in a reverse “balanced force” action using a pre-programmed motor to move the files in a back and forth “reciprocal motion”[21]. The motor is programmed such that the counter clockwise movement is greater than the clockwise movement; three reciprocating cycles complete one reverse rotation.

Neoendo file (NF) is another newer file system introduced with gold thermal treatment which enhances its cutting efficiency. It has got a triangular cross section with sharp cutting edge. Active cutting blades show better canal cleanliness than instruments with radial lands. The non cutting or safety tips in this file helps in reduction of procedural errors including root perforation, zipping and ledging.

The purpose of this study was to confirm presence of furcal groove in palatal aspect of buccal root of BMFP, measuring minimum cross-sectional dentine cementum wall thickness in the groove before and after instrumentation with WaveOne, Neoendo file and stainless steel K- files using limited field CBCT.

Aim and Objectives

AIM AND OBJECTIVES

AIM:

The aim of this *in vitro* study is to conduct a morphometric analysis on the buccal furcation grooves in extracted bifurcated maxillary first premolars (BMFPs) and to correlate anatomical measurements using CBCT before and after cleaning and shaping using three file systems - stainless steel K file, Wave One, NeoEndo file.

OBJECTIVES:

- Confirm presence of furcal groove in palatal aspect of buccal root in BMFP
- Location of the minimum cross-sectional dentin cementum wall (DCW) thickness in the furcal groove.
- Measure minimum cross sectional dentin cementum wall thickness in furcal groove in BMFP groove before and after cleaning and shaping.

Review of Literature

REVIEW OF LITERATURE

Caputo AA and Standlee JP (1976)[9] reviewed on the topic of pins and posts in endodontics. They noted that pins and posts retain restorations and protect remaining tooth structure; they are indispensable to conservative operative dentistry. Effective utilization of these pin-post systems requires application of proper biomechanical principles for each clinical situation. A parallel, serrated, cemented device in a precise matched channel is the ideal combination of characteristics. When tooth morphology or heavy function requires increased retention, it may be achieved by increasing pin-post length, diameter, and number or by utilizing the resilience of dentin. Optimal long range results will be obtained by utilizing pins and posts in conjunction with veneer types of restorations. When used in this manner, they will save many teeth each year and simultaneously reduce the rate of failures.

Gher ME and Vernino AR (1980)[20] have studied about root morphology and its clinical significance in pathogenesis and treatment of periodontal disease. In this study, teeth with representative root anatomy were sectioned and photographed. The photographs are intended as a visual presentation of various root morphologies and their potential implications in the practice of periodontics. They have noted that the shape of the roots may contribute to development of periodontal defects by providing an environment favorable to the retention of plaque.

Bystrom A and Sundqvist G (1981)[8] evaluated of the bacteriologic efficacy of mechanical root canal instrumentation in endodontic therapy. They studied the presence of bacteria in 17 single-rooted teeth, with periapical lesions throughout a whole period of treatment. The root canals were irrigated with physiologic saline solution during instrumentation. Bacteria were found in all initial specimens from the teeth. Mechanical instrumentation reduced the number of bacteria considerably. Specimens taken at the beginning of each appointment usually contained 10(4) - 10(6) bacterial cells and at the end 10(2) - 10(3) fewer. There was no evidence that specific microorganisms were implicated in these persistent infections. Teeth where the infection persisted despite being treated five times were those with a high number of bacteria in the initial sample.

Carter JM et al (1983)[10] tested the shear strength of cut human dentin specimens from vital and endodontically treated teeth using the punch shear test. It was found that shear strength values correlated positively with approximate toughness values. Statistically significant differences were found between shear strength and toughness values for vital and endodontically treated teeth, the latter showing lower values. Therefore in this study, it was quantities that endodontically treated teeth are weaker and more brittle than vital teeth.

Chow TW (1983)[13] studied the mechanical effectiveness of conventional root canal irrigation using hypodermic needle and syringe and was carried out using an artificial system of standardized root canals and particles. The influence of needle size, the depth of insertion of the needle, and the pressure of irrigation on the effectiveness of irrigating the apical portion of root canals was investigated.

Booker BW and Loughlin DM (1985)[6] have done a study on the morphologic aspects of the mesial root surface of the adolescent maxillary first bicuspid. Fifty extracted adolescent maxillary first bicuspids were sectioned in 2-mm thick sections apical to the cementoenamel junction (CEJ). The mesial concavity depth and the cementum and dentin thickness were measured in the sections. It was found that the single-rooted bicuspids have a concavity 0.35 mm deep at the CEJ and a concavity 0.59 mm deep 4.7 mm apical to the CEJ. Two-rooted bicuspids furcate at 7.9 mm and have a concavity 0.44 mm deep at the CEJ which increases to 1.08 mm at the 4.7 mm level. Cementum thickness averages from 0.9 mm at the CEJ to 1.1 mm at the 9.4-mm level. Most bicuspids also have a distal concavity which is deepest at the 4.7-mm level. Thus the results implied that any attachment loss around the maxillary first bicuspid involves surfaces which are most likely concave.

Lim S and Stock C (1987)[18] compared the risk of perforation in a curved canal between ant curvature filing using the step back technique and the standard circumferential step back method, in the mesial roots of 30 extracted human mandibular teeth. A greater risk of perforation into the furcation was found at a level 8 mm from the apex than at 5 mm. It was shown that anticurvature filing reduced the risk of perforation through the furcal surface of the root.

Tamse A (1988)[51] surveyed the iatrogenic vertical root fractures in endodontically treated teeth. It revealed that the most common cause of vertical root fracture in endodontically treated teeth is the excessive force used during lateral condensation of gutta-percha. Widening of the periodontal ligament along one or both sides of the root, or bone loss in solitary tooth are the major radiographic findings. Mild pain or discomfort and swelling are the major clinical symptoms, and solitary pocket around one aspect of the suspect tooth is the major clinical sign.

Walia H et al (1988)[56] conducted a study to determine whether rotary nickel-titanium (NiTi) canal preparation strengthens roots, and whether the fracture pattern can be predicted by finite element analysis (FEA) models. 25 teeth were prepared using hand files and another 25 using rotary NiTi. After obturation, all teeth were subject to loading until fracture; load and patterns were recorded. It was concluded that mesio-distal fracture occurred more often in the rotary NiTi group. Stress patterns in three of the four FEA models correlated well with the observed fracture patterns.

Haddix JE et al (1990)[24] investigated quantitatively the effect of the method of gutta-percha removal on the apical seal and evaluated apical leakage in teeth with different levels of remaining gutta-percha. The methods evaluated included the GPX instrument, heated pluggers, and Gates-Glidden drills. Groups of 25 extracted teeth were prepared with each of the three methods leaving 3 mm or 5 mm of gutta-percha remaining apically. Spectrophotometry (optical density) was used to assess apical leakage. It was observed that significantly less leakage was resent with the heated plugger technique at the 3 mm and 5 mm levels when compared to the 3 mm and 5 mm levels in both the GPX and Gates-Glidden groups.

Howe CA and McKendry DJ (1990)[25] compared the fracture resistance of intact human mandibular molars with molars after varied tooth preparation. Forty freshly extracted, non-carious, nonrestored human mandibular molars were randomly divided into four treatment groups. The molars were subjected to constantly increasing occlusal load until coronal-radicular fracture occurred. It was concluded that tooth preparations significantly diminished resistance to coronal-radicular fracture.

McCann J et al (1990)[37] assessed the diagnostic ability of cone beam computed tomography (CBCT) scans with different voxel resolutions in the detection of simulated external root resorption (ERR). For that purpose, 59 teeth were viewed and a calibrated examiner blinded to the protocol assessed the images through the i-CAT View software. It was concluded that CBCT is a reliable method for the investigation of simulated ERR, and a 0.3-mm voxel appeared to be the best protocol, associating good diagnostic performance with lower X-ray exposure.

Sjogren U et al (1990)[48] evaluated the influence of various factors that may affect the outcome of root canal therapy .356 patients were studied for 8 to 10 yr after the treatment. The results showed that the rate of success for cases with vital or nonvital pulps but having no periapical radiolucency exceeded 96%, whereas only 86% of the cases with pulp necrosis and periapical radiolucency showed apical healing. The possibility of instrumenting the root canal to its full length and the level of root filling significantly affected the outcome of treatment. Of all of the periapical lesions present on previously root-filled teeth, only 62% healed after retreatment. The predictability from clinical and radiographic signs of the treatment-outcome in individual cases with preoperative periapical lesions cases was found to be low.

Vire ED (1991)[55] evaluated and classified the failure of endodontically treated teeth. The 116 teeth were collected and classified into major failure categories of prosthetic, periodontic, and endodontic origin. Of the teeth, 59.4% were prosthetic failures which were due primarily to crown fracture. It was shown that teeth that had been crowned had greater longevity than uncrowned teeth. Periodontal failures constituted 32% of the study. Only 8.6% of the failures were due to endodontic causes, but these failures became evident more quickly than those in the other categories.

Gutmann JL (1992)[23] discussed the dentin root complex and its anatomic and biologic considerations in restoring endodontically treated teeth. The restoration of endodontically treated teeth has been the focus of considerable controversy and empiricism. It was concluded that there should be a thorough understanding of the anatomy and biology of the dentin and root supporting the restoration on the part of the practitioner, because both endodontic and restorative procedures alter the hard tissues.

Testori T et al (1993)[53] studied vertical root fractures in endodontically treated teeth. Vertical root fractures most frequently occur in posterior teeth in patients between 45 and 60 yr of age. The average elapsed time between the endodontic treatment and the subsequent diagnosis of vertical fracture was found to be approximately 10 yr. The evidence and symptoms most often found are mild pain in the area of the fractured tooth often accompanied by swelling and fistula, along with a deep pocket in just one area of the attachment surrounding the tooth. The sign most often revealed by X-ray is a radiolucent periradicular band.

Wayman BE et al (1994)[57] conducted a survey to determine the relative frequency of teeth needing endodontic treatment in 3350 consecutive endodontic patients. At the time of initial examination, 3672 teeth required root canal therapy. Posterior teeth were most frequently treated, 80.1% of the total with molars requiring 52.6% of the needed endodontic treatment. The mandibular first molar was treated most often, 18.8% of the time, followed by the maxillary first molar (13.5%) and the mandibular second molar (12.0%). It was found that the number of endodontically treated maxillary and mandibular teeth was similar, 50.8% and 49.2%, respectively.

Nielsen RB (1995)[40] evaluated the value of microcomputed tomography (MCT) for use in endodontic research. Four periodontally involved highly calcified maxillary first molars were extracted and then scanned for evaluation. The teeth were then instrumented, and 2 of the 4 obturated before rescanning for comparison evaluation. Several capabilities of the MCT to advance endodontic research significantly were observed: the ability of the MCT to present accurately the external and internal morphologies of the tooth without tooth destruction; the possibility of showing changes over time in surface areas and volumes of tissues; the ability to assess area and volume changes after instrumentation or obturation; and the capability of evaluating canal transportation following instrumentation or instrumentation and obturation. The tremendous potential of this scientific tool was discussed.

Gluskin AH et al (1995)[22] investigated the retention and fracture characteristics of lower incisors restored with variable dowel designs. Fifty freshly extracted mandibular incisors were endodontically treated. Four groups of 10 teeth decoronalized and dowel- and core-restored, were tested for retention characteristics and fracture resistance. Dowel variables included a prefabricated round cross-sectional design and a morphologic dowel that reproduced the canal space. It was found that no difference in resistance to transverse loading between morphological and standardized dowels .However, when analyzing modes of failure, ferruled morphological post and core design was less likely to result in a catastrophic root or post fracture. In addition, morphological dowels were significantly more retentive than standardized round dowels in teeth with narrow cross-sections .This study reaffirmed the findings of previous investigations, that the intact natural crown of an endodontically treated tooth provides maximum resistance to root fracture.

Dowker SE et al (1997)[14] summarized about X-ray micro tomography: nondestructive three-dimensional imaging for in vitro endodontic studies. The application of a laboratory x-ray micro tomography system, a miniaturized form of conventional computerized axial tomography, to the study of root canal morphologic characteristics and changes in the course of root canal treatment in extracted teeth The root canal systems and changes in these were imaged at a resolution (cubic voxel side-length) of approximately 40 microns.

Zaatar EI et al (1997)[59] conducted a retrospective study to evaluate the radiographic films of 846 endodontically treated teeth in Kuwait. It was found that the most frequently treated tooth was the mandibular first molar (17.4%).

Portenier I et al (1998)[44] measured the preparation of the apical part of the root canal by the lightspeed and step-back techniques. Experimental roots (n = 9 per group), embedded in clear plastic, were cross-sectioned using a 0.1-mm-thick band saw at distances 1.25 mm, 3.25 mm and 5.25 mm from the apices. Each sectioned root was then reassembled and the canals shaped by the step-back or Lightspeed technique. File size 40 and instrument size 50 were selected as the master apical file and master apical rotary for the step-back and Lightspeed groups, respectively. Displacements of the root canal centers before and after preparation were assessed in relation to the cross-sectional diameter of the files or instruments used. In addition, increases in cross-sectional area of the root canals after preparation were evaluated in relation to the cross-sectional area of the files or instruments used. Engine-driven nickel-titanium Lightspeed instruments caused significantly less displacement of the canal centers, so roots in the Lightspeed group remained better centered than those in the step-back group.

Tamse A et al (2000)[52] assessed the furcation groove on buccal root of maxillary first premolars. 35 maxillary first premolars were randomly selected and the buccal roots were sectioned into slices, 1 mm thick, and morphometric horizontal and vertical measurements were taken. The slice with the deepest invaginations served as the reference plane. The deepest invaginations were found to be at a mean distance of 1.18 mm from the bifurcation, with a mean depth of 0.4 mm. It was found that the furcation groove existed in 97% of the samples. The canal had a kidney-shaped appearance in cross-section, and the mean distance from the invagination to the canal wall was 0.81 mm. It is thus concluded that the use of rotary instruments for flaring these roots are hazardous and any circular-shaped post space preparation at this level is not indicated. The outcome of such procedures might be root thinning, perforation, or vertical root fracture, thus causing a poor prognosis.

Park H (2001)[32] evaluated the ability of engine-driven nickel-titanium files to maintain the original curvature of root canals during canal preparation. A total of 36 simulated curved canals on resin blocks were instrumented with Greater Taper (GT) files, ProFiles, and stainless steel files. The analysis of variance test was used for the statistical analysis of data obtained. It was found that the canals prepared by means of a ProFile with a 6% taper up to the working length were excellent in taper and in maintaining the original curvature. The canals prepared with GT files were also found to be excellent in taper and in maintaining the original curvature. It was concluded that the canals prepared with GT files and ProFiles were excellently tapered and maintained the original curvature of the canals in comparison with the ones prepared with stainless steel files.

Fuss Z et al (2001)[16] evaluated the role of operative procedures in the etiology of vertical root fracture of endodontically treated teeth. A total of 154 endodontically treated vertical root fractured teeth were used. Periapical radiographs before extraction, clinical findings and previous operative procedures were recorded. A post was observed in 95 teeth (61.7%), with 66 of these ending at the coronal third of the root. Most were screw posts of the Dentatus type (n = 64) and tapered cast posts (n = 14). A full crown was observed in 118 teeth, and 65 of these (55%) were extracted between 1 to 5 yr after final restoration. In 24 crowned teeth extraction was conducted within 1 yr after restoration and in 28 teeth after >5 years. It was concluded that post placement and root canal treatment are the major etiological factors for root fractures. Because signs and symptoms can appear years after the operative procedures in the root have been completed, coronal restorations would not interfere with the correct clinical diagnosis of vertical root fractures.

Bellucci S and Perrini N (2002)[5] conducted a study to measure the thickness of radicular dentine and cementum in incisors, canines and premolars. The roots of 220 extracted human teeth were sectioned in three horizontal parallel planes and measured using an optical microscope. For each cut surface buccal, lingual, mesial, and distal thickness of the root wall was measured. Mean values of the thickness were calculated and compared .It was found that maxillary central incisors and maxillary canines had the greatest widths. In all teeth with a single root, the wall thicknesses were greater on the lingual side than the buccal side. The study concluded that wall thickness varied greatly. The lingual surfaces of roots were larger. All roots had thin walls in the apical third.

Wu MK et al (2002)[58] conducted a study to determine whether the first file that binds at the working length corresponds to the canal diameter. Two similar groups of mandibular premolars with curved canals were selected and the first instrument that bound in each canal at the working length was determined. In one group the instrument used was a K-file; in the other group a Lightspeed instrument was used. After fixing the instruments in place, the apices were ground to the level of the working length and the diameters of both the instrument and the apical canal were recorded. It was seen that 75% of the canals had the instruments bound at one side of the wall in the others the instrument did not contact the wall. In 90% of the canals, the diameter of the instrument was smaller than the short diameter of the canal; this discrepancy was up to 0.19 mm. It was concluded that neither the first K-file nor the first Lightspeed instrument that bound at the working length accurately reflected the diameter of the apical canal in curved mandibular premolars.

Lertchirakarn V et al (2003)[19] studied the relative contribution of canal size and shape, external root morphology, and dentin thickness to vertical root fracture .Models were constructed based on cross-sections of human tooth roots that had been fractured clinically or experimentally. It was demonstrated that canal curvature seems more important than external root morphology, in terms of stress concentration, and that reduced dentin thickness increases the magnitude but not the direction of maximum tensile stress. It was shown that a strong similarity existed between tensile-stress distribution and fracture patterns.

Kobayashi K (2004)[33] evaluated the accuracy in measurement of distance using limited cone-beam computerized tomography .This study used a modified Bramante technique and new digital subtraction software to compare root canals prepared by nickel-titanium (Ni-Ti) hand, Ni-Ti engine-driven, and stainless steel hand endodontic instruments. Sixty mesial canals of extracted human mandibular molars were randomly divided into five groups. It was found that engine-driven

Ni-Ti instruments (Lightspeed and NT Sensor file) and hand instrumentation with the Canal Master "U" caused significantly less canal transportation, remained more centered in the canal , removed less dentin and produced rounder canal preparations than K-Flex. Engine instrumentation with Lightspeed and NT Sensor file was significantly faster than hand instrumentation.

Peters OA (2004)[42] reviewed the current challenges and concepts in the preparation of root canal systems and to identify factors that influence shaping outcomes with these files, such as preoperative root-canal anatomy and instrument tip design. Despite the existence of one ever-present risk factor, dental anatomy, shaping outcomes with nickel-titanium rotary instruments are mostly predictable. Nickel-titanium rotary instruments require a preclinical training period to minimize separation risks and should be used to case-related working lengths and apical widths.

Albrecht L et al (2004)[1] evaluated the effect of preparation taper using size #20 or size #40 ProFile GT files on the ability to introduce irrigant and remove debris from root canals. Forty-eight bilaterally matched pairs of extracted teeth were instrumented using.04-, .06-, .08-, and.10-tapered files with one tooth of each pair enlarged to size #20 and the other to size #40. The following variables were evaluated: apical preparation size, preparation taper, total volume of irrigation, depth of irrigation needle penetration, and number of instrument changes needed to reach working length. It was found that compared with the size #40 preparations, a significantly greater percentage of remaining debris was observed in the size #20 preparations at the 1-mm level for all tapers .It was concluded that debris is more effectively removed using.04, .06, and.08 ProFile GT instruments when the apical preparation size is larger (size #40) compared with size #20 apical preparations. When a taper of.10 can be produced at the apical extent of the canal, there is no difference in debris removal between the two preparations sizes.

Sathorn C et al (2005)[47] conducted a study to determine 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 a mandibular incisor was created by averaging the dimensions of 10 extracted teeth, and then the basic finite element analysis (FEA) model was created. By varying canal diameter, shape, and proximal concavity, these factors could be examined for roles in fracture susceptibility and pattern. It was concluded that 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 increased fracture susceptibility.

Bajaj D et al (2006)[4] studied the effects of age and dehydration on fatigue crack growth in human dentin. Compact tension (CT) fatigue specimens of coronal dentin were prepared from extracted molars and subjected to high cycle fatigue loading. Young hydrated dentin, old hydrated dentin and young dehydrated dentin were examined. Fatigue crack growth rates were quantified .It was found that the average fatigue crack growth exponent for the young hydrated dentin was significantly less than that for the hydrated old and dehydrated young dentin. Differences in the microscopic features of the fracture surfaces from the old and young dentin suggested that particular mechanisms contributing to energy dissipation and crack growth resistance in the young hydrated dentin were not present in the old dentin. Based on results of this study, it was concluded that the fatigue crack growth resistance of human dentin decreases with both age of the tissue and dehydration.

Katz A et al (2006)[28] evaluated the changes in dentin thickness and structures adjacent to the furcal groove. The sample size of 20 was selected and three horizontal slices were made to the buccal root, coronal, middle, and apical. The angles of the grooves and dentin thickness were measured with a profile projector. It was concluded that dentin thickness corresponding to the furcal groove is variable and it presents structural changes and must be taken into account in endodontic and prosthetic procedures.

Cohen S et al (2006)[11] analyzed different variables and evaluated their correlation with the presence of vertical root fractures. Specifically analyzed variables were gender, tooth location, age, radiographic and clinical findings, bruxism, and pulpal status. It was found that VRFs are statistically more prevalent in mandibular molars and maxillary premolars. They are associated with periradicular bone loss, pain to percussion, extensive restorations and occur more often in females and older patients. However, VRFs are not necessarily related to periapical bone loss, a widening of the periodontal ligament space, associated periodontal pockets, a sinus tract, particular pulpal status or bruxism.

Zandbiglari T et al (2006)[61] compared the force required to fracture uninstrumented and instrumented canines and to investigate the root-reinforcing capability of AH Plus sealer. In groups 1-3 (n = 24) canals were instrumented with GT files, FlexMaster, or stainless steel hand instruments. Twelve teeth from each group were obturated with lateral compaction using gutta-percha and AH Plus. The force required to fracture the roots was measured. It was found that the intact roots were significantly stronger than all groups with instrumented and unobturated roots Roots enlarged with GT files were significantly weaker than those instrumented with FlexMaster or hand instruments. It was concluded that roots were significantly weakened by the preparation with greater taper instruments. Obturation with AH Plus did not increase the fracture resistance.

Rundquist BD and Versluis A (2006)[45] examined the effect of specific tapers on root stresses and thus vertical root fracture. Stresses in the dentine were observed whilst the root was filled with three subsequent gutta-percha increments. Each increment was compacted at 10 or 15 N and the gutta-percha cooled down. The stress distribution in the root during the occlusal loading was compared with the stresses during filling. It was shown that during filling, the highest stresses were found: (a) at the canal surface; (b) using the smallest taper; (c) in the apical third; and (d) during the first gutta-percha increment. It generated the highest stresses at the external root surface, with a tensile stress concentration at the lingual surface of the cervical third. It was concluded that with increasing taper, root stresses decreased during root filling but tended to increase for masticatory loading. Root fracture originating at the apical third is likely initiated during filling, whilst fracture originating in the cervical portion is likely caused by occlusal loads.

Kishen A (2006)[30] discussed the mechanisms and risk factors for fracture predilection in endodontically treated teeth. Different mechanisms of fracture resistance in dentine and the biomechanical causes of fracture predilection in restored endodontically treated teeth are described. Furthermore, dentinal, restorative, chemical, microbial, and age-induced factors that predispose restored endodontically treated teeth to fracture are also reviewed.

Mickel AK et al (2007)[38] compared file sizes that bind at the apex before and during crown-down preparation and assessed the relation between apical size and extent of intracanal bacterial load. There were 100 single-rooted teeth biomechanically prepared after inoculation with Enterococcus faecalis. Canals were preflared, and apical size was ascertained by the first file to bind (FAB) at the working length (WL). During crown-down preparation, the first crown-down file to reach the apex during instrumentation was noted (CDF). Teeth were then divided into three master apical file size groups of CDF + 1, CDF + 2, and CDF + 3. The samples were then cultured for intracanal bacterial counts. Fifteen samples and four controls were analyzed under SEM. It was demonstrated to be an average of four file sizes larger than the FAB. SEM observation revealed bacteria on dentinal walls and in tubules even in most negative canal cultures.

Cotton T et al (2007)[12] discussed about the endodontic applications of Cone Beam Volumetric Tomography. As opposed to sliced-image data of conventional computed tomography (CT) imaging, CBVT captures a cylindrical volume of data in one acquisition and thus offers distinct advantages over conventional medical CT. These advantages include increased accuracy, higher resolution, scan-time reduction, and dose reduction. Specific endodontic applications of CBVT are being identified as the technology becomes more prevalent. CBVT has great potential to become a valuable tool in the modern endodontic practice. The objectives of this article are to briefly review cone-beam technology and its advantages over medical CT and conventional radiography, to illustrate current and future clinical applications of cone-beam technology in endodontic practice, and to discuss medico legal considerations pertaining to the acquisition and interpretation of 3-dimensional data.

Patel S et al (2007)[41] summarized on cone beam computed tomography (CBCT) technology and its potential applications in endodontic practice. CBCT has been specifically designed to produce undistorted three-dimensional information of the maxillofacial skeleton as well as three-dimensional images of the teeth and their surrounding tissues. Periapical disease may be detected sooner using CBCT compared with periapical views, and the true size, extent, nature and position of periapical and resorptive lesions can be assessed. Root fractures, root canal anatomy and the true nature of the alveolar bone topography around teeth may be assessed. CBCT scans are desirable to assess posterior teeth prior to periapical surgery, as the thickness of the cortical and cancellous bone can be accurately determined as can the inclination of roots in relation to the surrounding jaw. The relationship of anatomical structures such as the maxillary sinus and inferior dental nerve to the root apices may also be clearly visualized.

Kim HC et al (2010)[29] compared the stress conditions during rotary instrumentation in a curved root for three NiTi file designs. Finite element (FE) analysis models of ProFile, ProTaper Universal and LightSpeed LSX were rotated within a curved root canal. The stress and strain conditions resulting from the simulated shaping action were evaluated in the apical root dentin. It was found that ProTaper Universal induced the highest von Mises stress concentration in the root dentin and had the highest tensile and compressive principal strain components at the external root surface. It was thus concluded that the stiffer file designs generated higher stress concentrations in the apical root dentin during shaping of the curved canal, which raises the risk of dentinal defects that may lead to apical root cracking.

Sarao SS et al (2013)[46] compared the thickness of dentin removed from the buccal root of bifurcated maxillary first premolars (BMFP) in the area of furcation groove after instrumentation with WaveOne and LightSpeed LSX files utilizing limited field cone beam computerized tomography. All data was analyzed using repeated-measured mixed-model .The thickness of dentin removed with LightSpeed LSX files (0.1 mm) was significantly less than the thickness of dentin removed with WaveOne files (0.2 mm).It was concluded that, LSX files remove a more predictable and consistent thickness of dentin from the buccal root of BMFP, irrespective of the pre-instrumentation thickness of dentin and the file size when compared to WO files that remove a more variable thickness of dentin.

Akhlaghi NM et al (2014)[50] conducted a study to evaluate the effect of size and taper of master apical file in reducing bacteria from the apical third of the curved canals using a quantitative scanning electron microscope study. Eightynine human mandibular first molars with curved MB canals (20°-35°) were divided into one control group (*n*=5) and 6 experimental groups . The canals were prepared using RaCe rotary files to the MAF sizes 25/0.04, 25/0.06, 30/0.04, 30/0.06, 35/0.04 and 35/0.06, in groups 1 to 6, respectively. All the experimental groups were finally rinsed with 2 mL of 17% EDTA followed by 3 mL of 5.25% NaOCl. The mesial roots were split longitudinally. Remaining bacteria in the apical third of MB canals were evaluated using SEM All the experimental groups showed significant bacterial reduction. Although the greater size and/or taper resulted in decrease in bacteria, differences between the groups were not significant.. Based on this *in vitro* study the MAF #25/0.04 had no significant -difference compared to other groups with greater apical size/taper; all groups could effectively reduce intra-canal bacteria.

Materials and Methods

MATERIALS AND METHODS

ARMAMENTARIUM:

- Extracted bifurcated maxillary first premolar
- Custom made wax block (Modelling wax No.2, Hindustan dental products, India)
- Endo access bur (DENTSPLY, Tulsa Dental)
- Endodontic explorer (DG-16; Hu-Friedy, Chicago, IL).
- 10 K-file (DENTSPLY Maillefer; Ballaigues, Switzerland)
- Stainless steel (SS) K-file (Mani ,Inc, Japan)
- Neoendo flex file (NF) (Orikam , India)
- WaveOne (WO) (DENTSPLY Tulsa Dental Specialties Inc.,)
- 5 ml syringe with a 27-gauge needle (Unolok, Hindustan syringes and medical devices LTD. India)
- 5.25% sodium hypochlorite (Prime dental PVT LTD, India)
- X- Ray unit - 6010E (Adithya medical systems Ltd, India.)
- X- Ray film (Carestream Health,Inc, Rochester, NY, USA)
- CS 9300 limited field CBCT (NewTom Vgi- Verona - Italy)
- HP desktop computer equipped with Carestream software

METHODOLOGY

105 BMFPs which were extracted for orthodontic purpose were collected from various dental clinics and stored in 10% neutral buffered formalin solution. The teeth were cleaned of any calculus or periodontal tissue remnants by scaling the root surface. Among the collected tooth five teeth were excluded - One tooth was used for a pilot study, two teeth because of the presence of more than one canal in the buccal root and three teeth were excluded due to apical fracture. Remaining ninety nine teeth (Fig 1) were then examined for the presence of the buccal furcation groove and confirmed. Each tooth was mounted on a custom made wax block.

Preliminary CBCT scan was done using CS 9300 limited field cone beam computed tomography (CBCT) (NewTom Vgi- Verona - Italy) machine (Fig 12) at BABA scans, Mylapore, Chennai. The field of view was set at 5 cm in diameter and 5 cm in height. The scan was set at 110 kV, 1-20 mA, with a voxel size of 90 micrometers. The slice thickness was 90 micrometers, which is the smallest measurable width possible on this machine. A pre-operative scan was obtained for each specimen (Fig 6,7,8). A desktop computer equipped with Carestream software and supporting hardware was used to make the measurements of both the pre-instrumentation and post-instrumentation images. Carestream software has advanced algorithms for more precise diagnosis with low dose and high image resolution up to 90 micrometer. The beginning and the end point of the scanning (on the z axis) were recorded to allow repeated scanning of the specimen at the same horizontal levels.

Dentine cementum wall thickness was measured within the axial plane at a specific location (slice levels) along the furcation groove for each respective tooth. (Fig 5) illustrates an example of each point or slice level measured along the furcation groove in a sagittal plane. The first slice (Point A) was measured at 0.5 mm apical to the coronal initiation point of the furcation groove. The third slice (Point B) was measured at 0.5 mm coronal to the termination of the furcation groove. The second slice (Point C) was measured at midpoint between the first and third slice respectively and was considered as the deepest point of invagination of groove. Dentine cementum wall thickness was measured within the axial plane at this level (Point C) considering it as deepest invagination of the furcation groove into the canal wall.

Dentine cementum wall thickness was measured between the deepest aspect of the furcation groove and the corresponding outer lingual wall of the canal. Figure 13 further depicts the method in which measurement of the dentine cementum wall thickness was completed. Two horizontal lines are drawn parallel to each other and separated by a perpendicular line. The first horizontal line was drawn on tangent with the deepest invagination point of the furcation groove. The second horizontal line was drawn on a tangent with the innermost lingual portion of the canal wall. The perpendicular line connects both horizontal lines and represents the DCW thickness present. All measurements were recorded in the axial plane in order to provide a repeatable horizontal measurement at the specified slice level.

In all the samples access cavity preparation was done using Endo access bur (Dentsply, Tulsa Dental) to ensure ideal straight line access (Fig 2). The principle canal orifices were identified with an endodontic explorer (DG-16; Hu-Friedy, Chicago, IL). The buccal canal of each tooth was explored for patency using a size 10 K-file (Dentsply Maillefer; Ballaigues, Switzerland). The teeth were then randomly divided into three groups, 33 teeth in each group.

Group I was instrumented with Stainless steel (SS) K-file (Mani ,Inc, Japan) up to apical 25 size, 2% taper.

Group II with Neoendo flex file (NF) (Orikam, India) up to apical 25 size, 4% taper.

Group III with WaveOne (WO) (Dentsply Tulsa Dental Specialties Inc., Tulsa OK) primary file 25 size, 8% taper.

A pre-operative working length was verified with a periapical radiograph taken by paralleling technique using X- Ray unit (AMS - 6010E) (Fig 4) and E-Speed X- Ray film (Carestream Health, Inc, Rochester, NY, USA) The working length was measured from the buccal cusp tip (coronal reference point) to radiographic apex (end point) (Fig 3). Canal irrigation was achieved with 5.25% sodium hypochlorite (Prime dental PVT LTD, India) during instrumentation and delivered into the canal by a 5 ml syringe with a 27 gauge side vented needle (Unolok, Hindustan syringes and medical devices LTD. India). For all the canals glide path was established using size #15k file. A patency file (#10 K-file) was used along with a copious irrigation of 5.25% NaOCl (Prime dental PVT LTD, India) after each successive hand and rotary file used.

In Group I all teeth were instrumented to an apical size #25 in crown down pressure less technique.

In Group II Neoendo flex files was used sequentially till size 0.04/#25.

In Group III WaveOne files was used. Currently there are three files available in the WaveOne single-file reciprocating system. The WaveOne Small file which has a tip size of ISO 20 with a continuous taper of 6%, WaveOne Primary file with tip size of ISO 25 and apical taper of 8% that reduces towards the coronal end. WaveOne large file has a tip size of ISO 40 and apical taper of 8% that reduces towards the coronal end. WaveOne small file is used when a #10 K-file is very resistant to movement till working length, and primary file is used when #10 K-file moves till working length easily and in large canals were #20 size k file goes till working length WaveOne Large file is used . In this study a #10 size K file easily negotiated the canal up to the apex. So a WaveOne primary file was used. Individual NiTi rotary files were limited to five uses.

After completing the instrumentation, all the samples were subjected to post operative CBCT scan. While analysing the images, the operator was blinded to the information of the type of instrument used in that particular tooth. This helped reduce the operator bias.

All the measurements at different slice levels were recorded for the post-instrumentation images (Fig 9,10,11). DCW thickness at Point C was measured and noted and the results were statistically analysed.

METHODOLOGY - FLOW CHART

Collection of Samples (99 untreated bifurcated maxillary 1st premolar)

↓

Preliminary scan using CBCT.

↓

Confirm presence of furcal groove in palatal aspect of buccal root using CBCT.

↓

Mark Point A - at 0.5 mm apical to the coronal initiation point of the furcation groove in palatal aspect of BMFPs

Point B - at 0.5 mm coronal to the termination of the furcation groove in palatal aspect of BMFPs.

Point C - marked at the median of Point A and Point B (considered as the deepest point of invagination of groove)

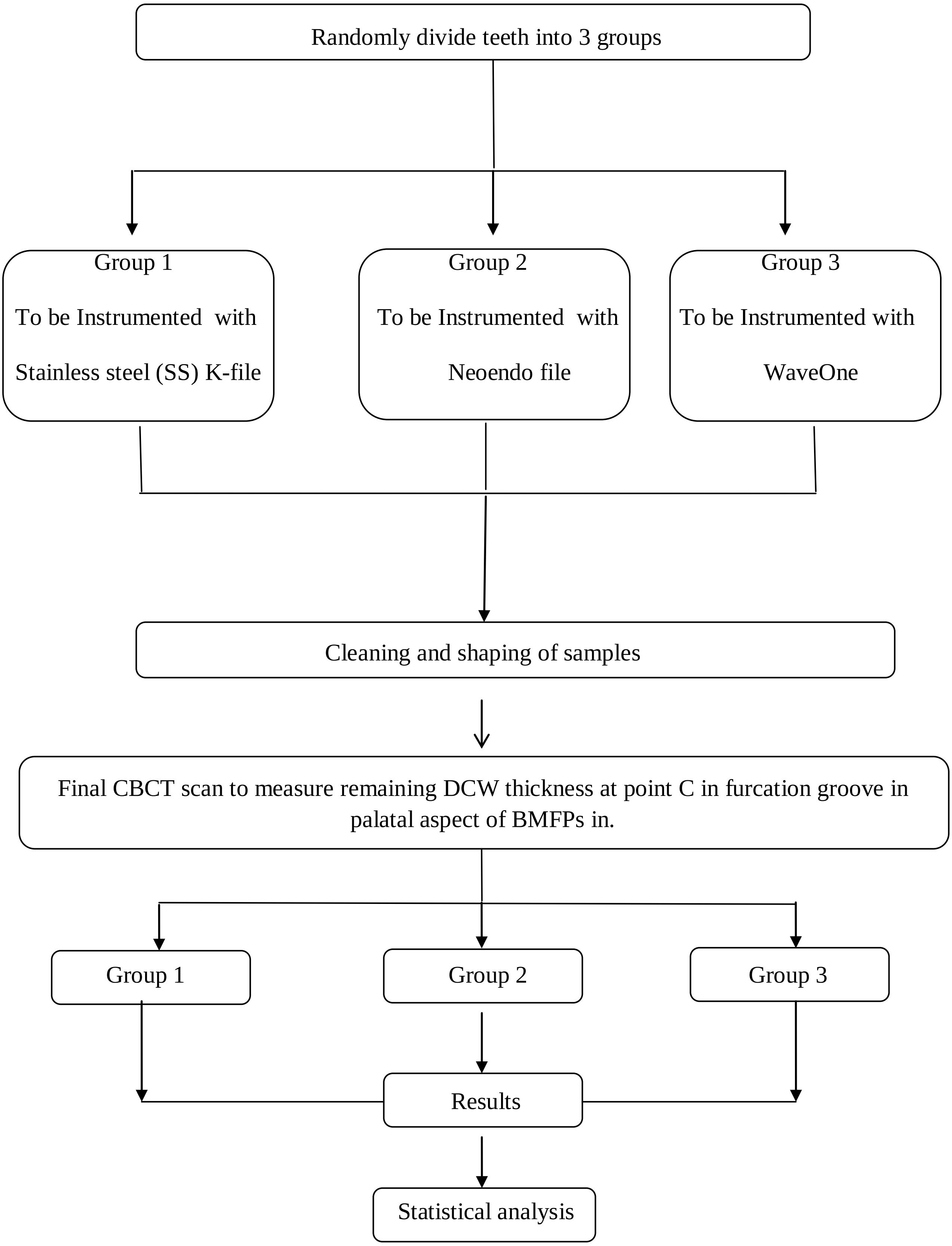
↓

Measure minimum cross sectional dentin cementum wall thickness (DCW) at point C

↓

Access opening of all samples

↓


Randomly divide teeth into 3 groups
Group 1
To be Instrumented with
Stainless steel (SS) K-file
Group 2
To be Instrumented with
Neoendo file
Group 3
To be Instrumented with
WaveOne
Cleaning and shaping of samples
Final CBCT scan to measure remaining DCW thickness at point C in furcation groove in palatal aspect of BMFPs in.
Group 1
Group 2
Group 3
Results
Statistical analysis

Figures

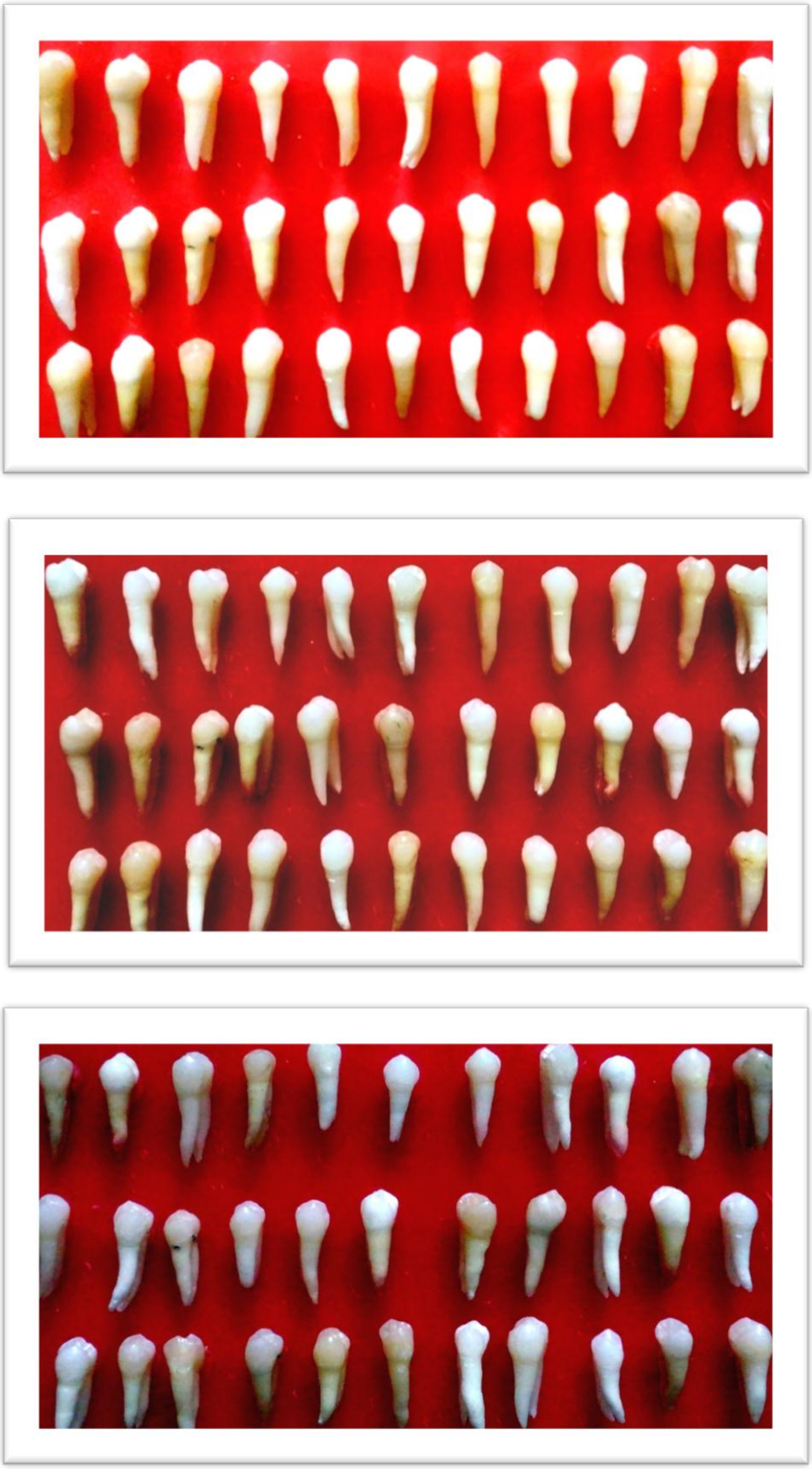


Figure 1:

Samples - Extracted bifurcated maxillary first premolar teeth

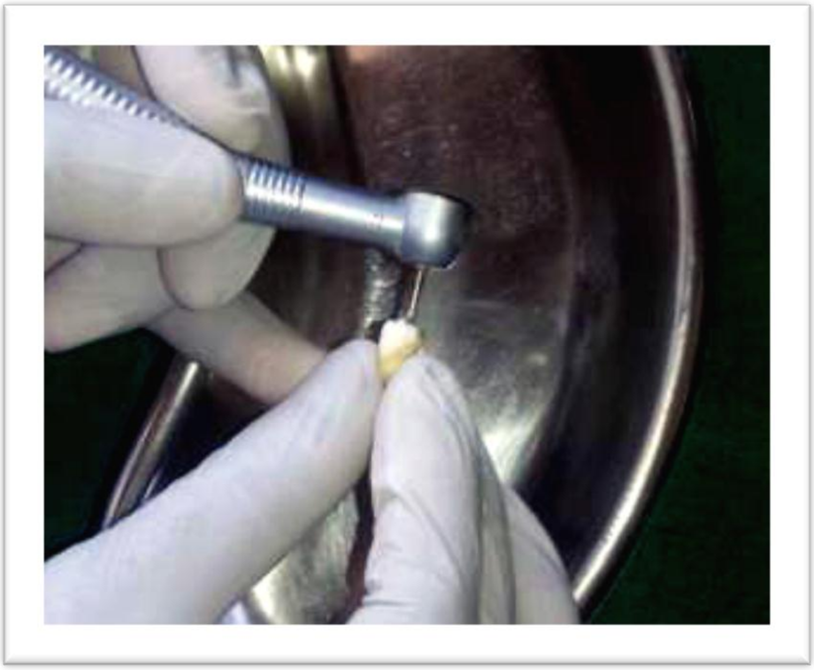


Figure 2:

Access cavity preparation

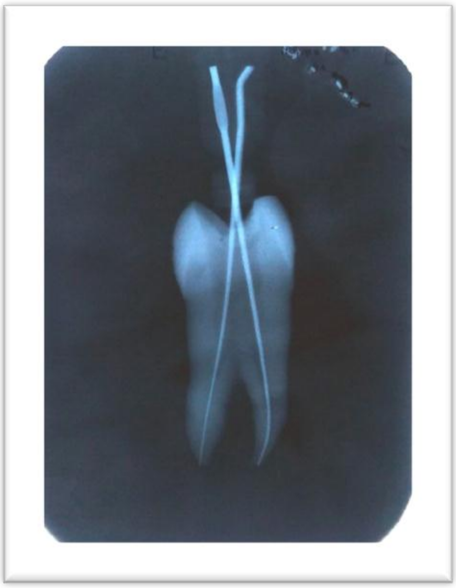


Figure 3:

Working length radiograph

Figure 4:

X - ray unit

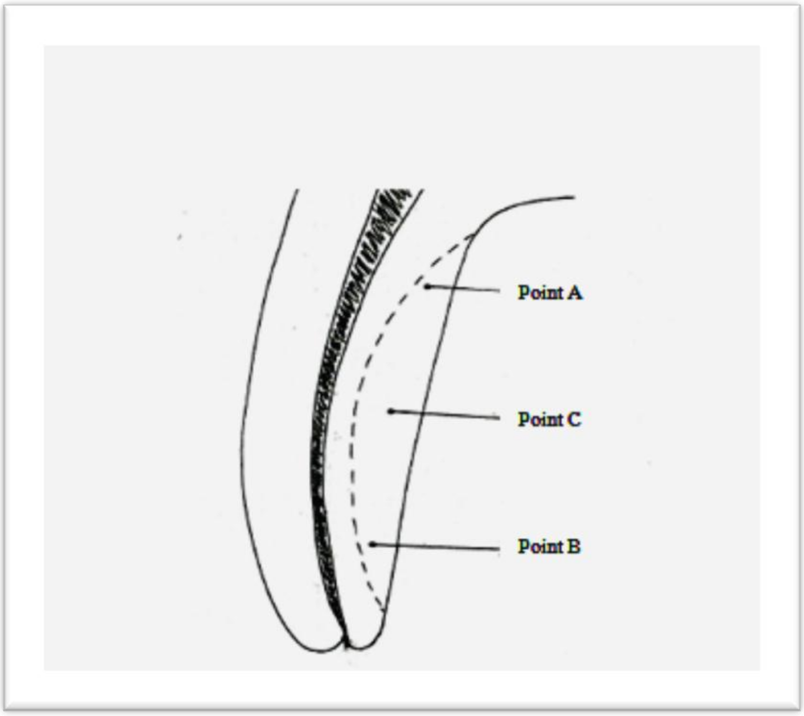


Figure 5:

Diagrammatic representation of maxillary first premolar Buccal Root in a Sagittal Plane Orientation.

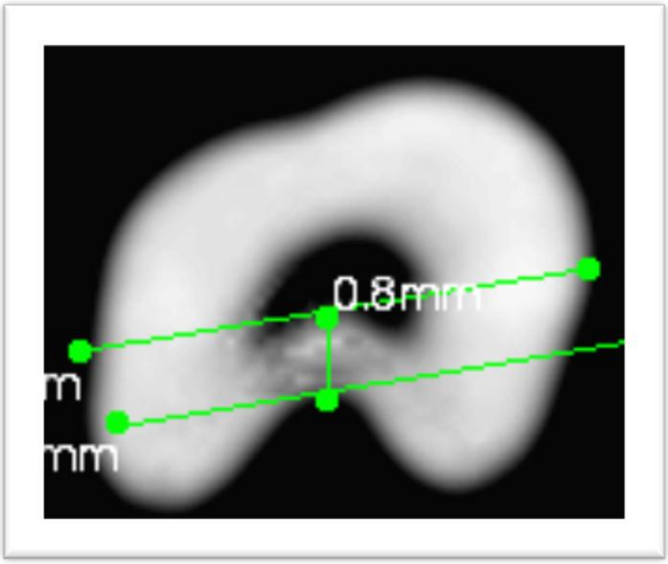


Figure 6:

Pre instrumentation CBCT image - Group 1

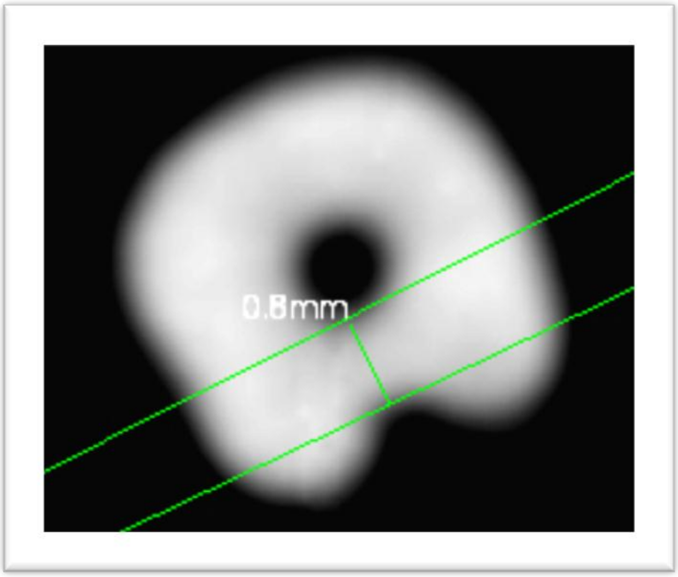


Figure 7:

Pre instrumentation CBCT image - Group 2

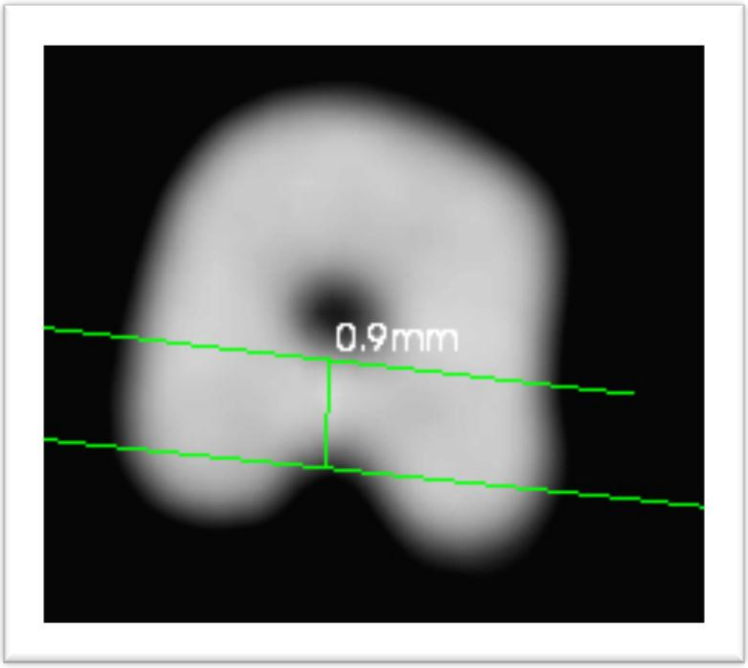


Figure 8:

Pre instrumentation CBCT image - Group 3

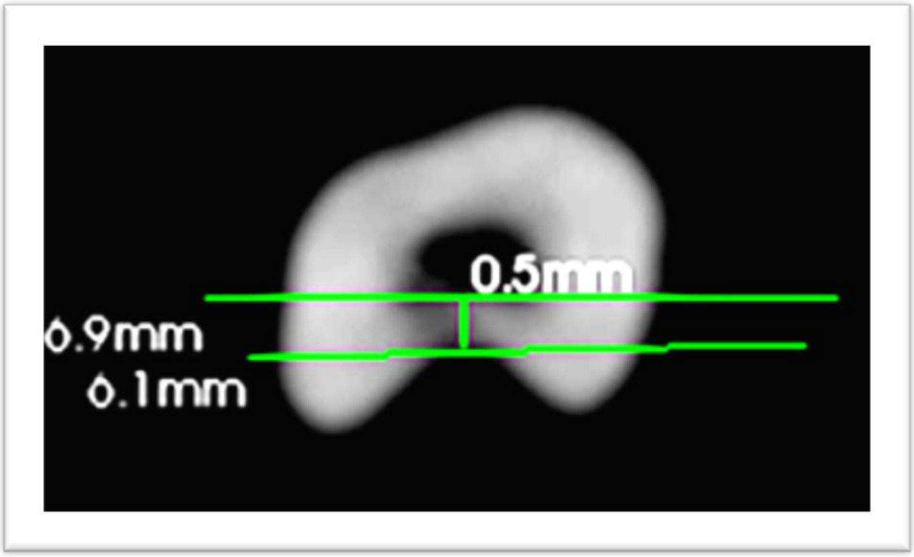


Figure 9:

Post instrumentation CBCT image - Group 1

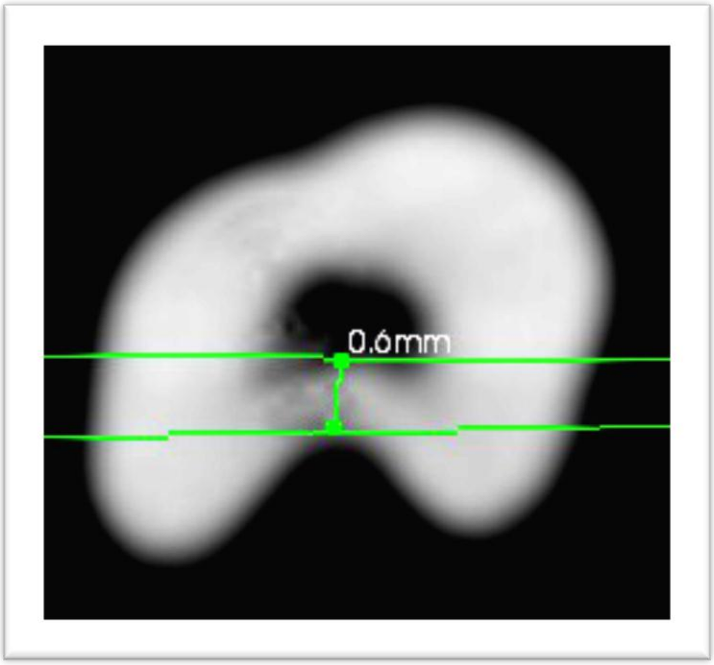


Figure 10:

Post instrumentation CBCT image - Group 2

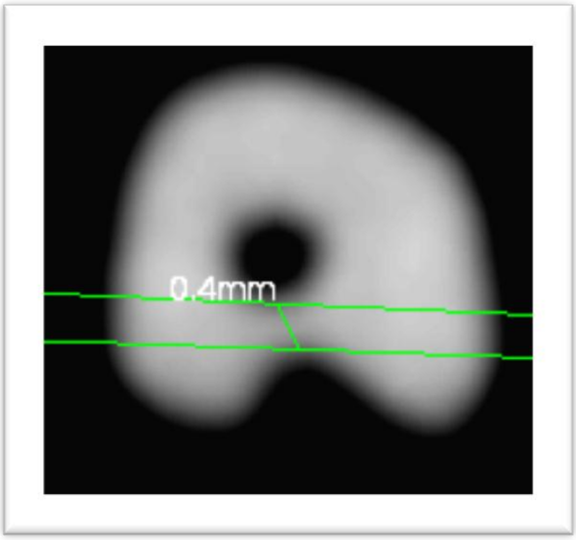


Figure 11:

Post instrumentation CBCT image - Group 3

Figure 12:

9300 limited field CBCT machine

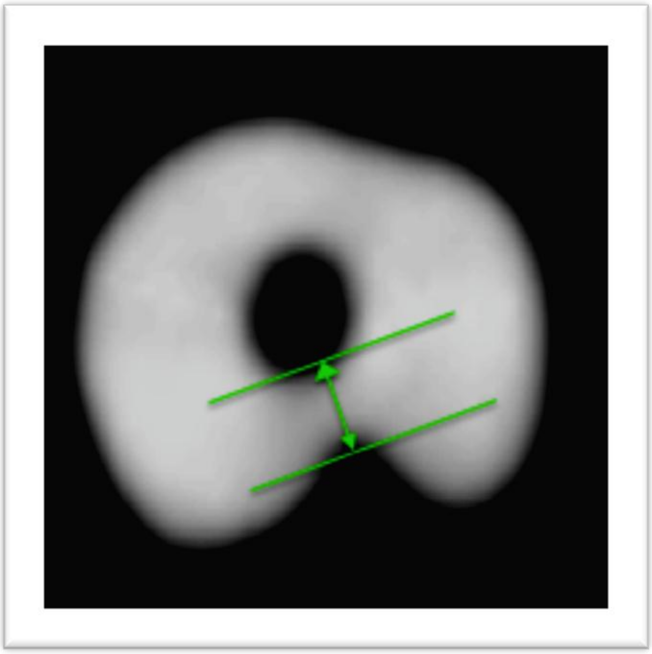


Figure 13:

Measurement of the dentine cementum wall thickness

Results

RESULTS

Results of the present study was subjected to statistical analysis to interpret the significance of instrumentation in the buccal root of bifurcated maxillary premolar and to correlate the palatal root canal wall thickness in buccal root. Data entry and data base management was done in SPSS (Statistical package for social work) version 20.0 for windows.

One way ANOVA was used for intergroup comparison of mean canal wall thickness pre and post instrumentation.

Bonferroni Post Hoc test was used for multiple comparison within the group and between the groups preoperative as well as the post operative.

Paired T-Test was used to find significance among each groups pre and post instrumentation.

The one-way analysis of variance (ANOVA) is used to determine whether there are any significant difference between the means of two or more independent groups.

A pos-hoc test is needed after an ANOVA is complete in order to determine which groups differ from each other. For the Tukey's post-hoc test the difference between the means of all of the groups are found. Difference of score is compared to a critical value to see if the difference is significant.

The paired sample t-test is used to compare mean of two groups where you have two samples in which observation in one sample can be paired with observations in other samples. In a paired sample t-test each subject or entity is measured twice, resulting in pairs of observation

Descriptive statistics are shown in both Table 1 and Table 2

Table 1 shows the descriptive statistics of pre-instrumentation lowest value of canal wall thickness, highest value of canal wall thickness, mean value of canal wall thickness and standard deviation of each group.

Table 2 shows the descriptive statistics - post-instrumentation lowest value of canal wall thickness, highest value of canal wall thickness, mean value of canal wall thickness and standard deviation of each group. The least mean value after instrumentation was found in group III (0.61 mm) which was followed by group I (0.73 mm) and group II (0.74 mm). This table also showed the thinnest canal wall in group III (0.35 mm).

Table 3 shows ANOVA between the groups in pre test group, shows a mean square of 0.009 with p value of 0.702 which is statistically insignificant.

Table 4 shows ANOVA between the groups in post test group, with p value showing 0.001 which imply significance at level one (Highly significant).

Table 5

Post Hoc Tests – pre instrumentation pair wise comparison between each groups and the significance between each group was analysed. There was no significant difference between the groups.

Table 6

Post Hoc Tests – post instrumentation pair wise comparison between each groups and the significance between each group was analysed. When comparing between group I and group II there is no significant difference, but when group I is compared with group III it showed statistically significant at level five. Comparison of group II and three showed statistical significant at level one (Highly significant).

Table 7

Paired sample test within group comparison – showed comparison within the groups and showed the pre and post instrumentation within the groups of all groups are statistically significant at level 1 (Highly significant)

Table 8

Shows the mean dentine removed by each of the groups. Group II had the least dentine removed followed by group I and group III showed the highest dentine removed.

Graph 1

Graph one shows pre and post instrumentation canal wall thickness. Group II shows the highest canal wall thickness after instrumentation.Group III shows the least canal wall thickness.

Graph 2

Graph two shows the mean dentine removed in each groups. Group II showed least dentine removed. Group III shows the highest dentine removal.

Tables and Graphs

Table 1

Descriptive Statistics

Shows mean value of canal wall thickness of all groups pre instrumentation.

Group		N	Minimum	Maximum	Mean	Std. Deviation
1	Pre	33	.60	1.20	.8879	.16537
2	Pre	33	.60	1.20	.8909	.15883
3	Pre	33	.60	1.20	.8606	.15799

Table 2

Shows mean value of canal wall thickness of all groups post instrumentation.

Groups		N	Minimum	Maximum	Mean	Std. Deviation
1	Post	33	.50	1.00	.7333	.14506
2	Post	33	.45	1.00	.7424	.14530
3	Post	33	.35	1.00	.6121	.16299

ONEWAY ANOVA

Table 3

Pre test ANOVA between groups.

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.018	2	.009	.356	.702

Table 4
Post test ANOVA between groups.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.349	2	.175	7.624	.001**

**p value < 0.010 is considered statistically significant at level 1 (Highly significant)

Post Hoc Tests

Table 5

Pre Test comparison - between groups.

Dependent Variable	(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval
						Lower Bound
Pre	1.00	2.00	-.00303	.03958	1.000	-.0995
		3.00	.02727	.03958	1.000	-.0692
	2.00	1.00	.00303	.03958	1.000	-.0934
		3.00	.03030	.03958	1.000	-.0661
	3.00	1.00	-.02727	.03958	1.000	-.1237
		2.00	-.03030	.03958	1.000	-.1267

Table 6

Post Test comparison - between groups.

Multiple Comparisons						
Dependent Variable	(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval
						Lower Bound
Post	1.00	2.00	-.00909	.03726	1.000	-.0999
		3.00	.12121*	.03726	.005	.0304
	2.00	1.00	.00909	.03726	1.000	-.0817
		3.00	.13030*	.03726	.002	.0395
	3.00	1.00	-.12121*	.03726	.005	-.2120
		2.00	-.13030*	.03726	.002	-.2211

**p value < 0.010 is considered statistically significant at level 1 (Highly significant)

*p value < 0.005 is considered statistically significant at level 5 (Significant)

Table 7

Paired sample test within group comparison

Paired Samples Test										
Groups			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
1.00	Pair 1	pre - post	.15455	.04395	.00765	.13896	.17013	20.199	32	.000
2.00	Pair 1	pre - post	.14848	.03850	.00670	.13483	.16214	22.157	32	.000
3.00	Pair 1	pre - post	.24848	.04590	.00799	.23221	.26476	31.097	32	.000

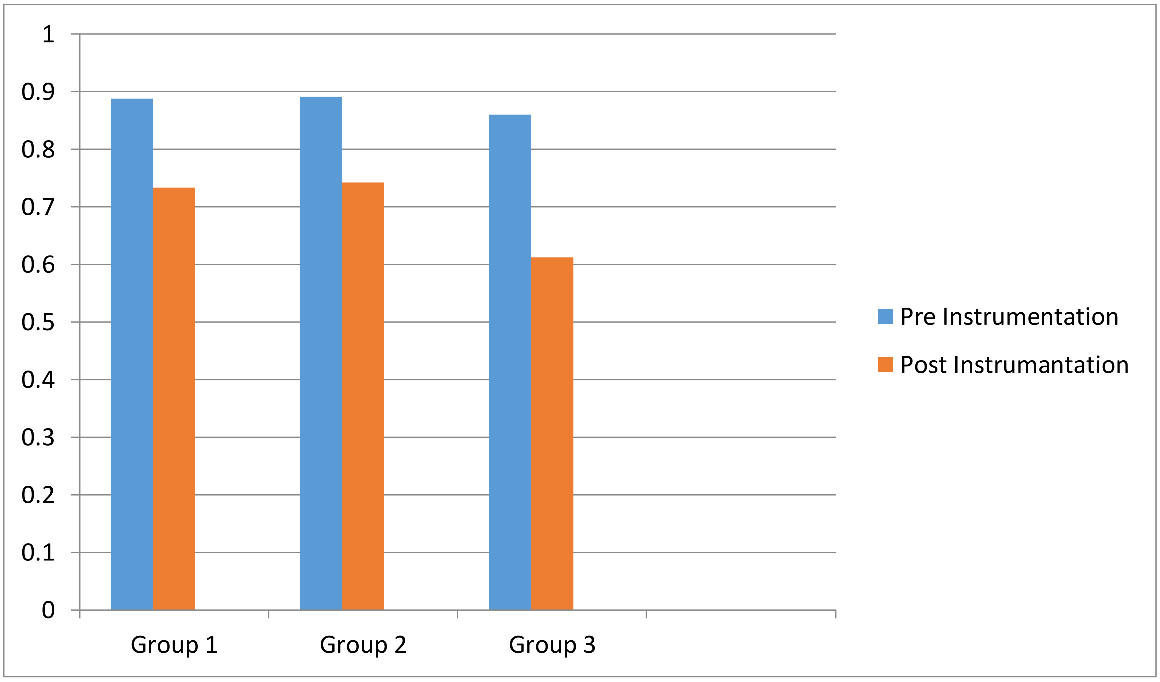
Table 8

Mean dentine removed by each group

		Mean
Group	Group 1	0.154
	Group 2	0.148
	Group 3	0.245

Graph 1

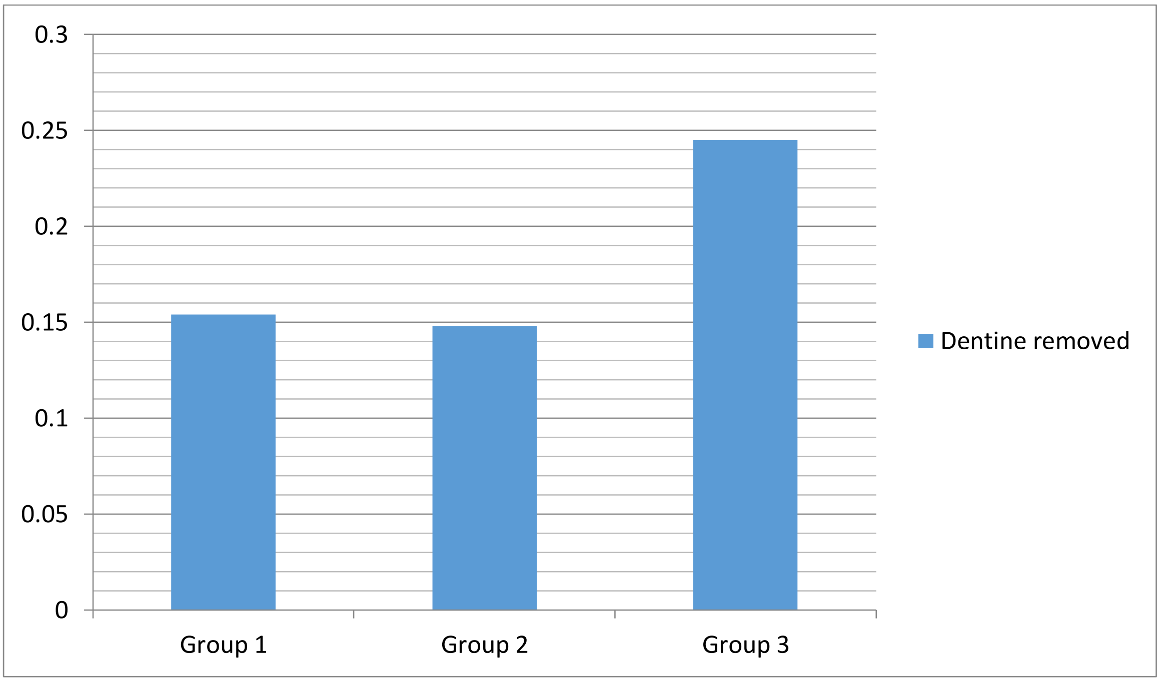
Graph showing pre and post instrumentation canal wall thickness



.

Graph 2

Dentine removed in each groups.



Discussion

DISCUSSION

Endodontic therapy encompasses treatment of coronal and radicular pulp so as to retain natural tooth in its form, function and aesthetics. It is mainly directed to a set of aims that is to cure or prevent periapical periodontitis[63]. As Gutmann described this aim is achieved by thorough debridement of the root canal space and neutralization of any remaining tissue, bacteria, bacterial by-products or inflammatory products within the root canal system by cleaning, shaping and subsequent filling of the canal space thus preventing or minimizing any chances of reinfection [8].

Although the complete eradication of microbes from root canal system is supposed to be the key to successful root canal treatment, it is nearly impossible to eliminate microbes completely from root canal system. Microbial samples taken and cultured from both successful and failed (reinfected) endodontic cases showed presence of bacteria and its by-products[6]. So rather than trying to eliminate entire microbes the focus must be to reduce the microbial load to make a favourable environment to prevent re-growth and persistent infection.

The concept of cleaning and shaping was introduced by Schilder. Cleaning refers to removal of contents of root canal system before and during mechanical shaping process, which involves organic substrates, pulp tissue, microorganism, necrotic dentin, debris etc. Efficacy of subsequent procedures is determined by proper shaping of the canals which includes mechanical debridement, creating space for medicaments and optimized canal geometry for adequate obturation[63].

Schilder suggested a continuous conical preparation from canal orifice to the root apex, keeping the narrowest cross sectional diameter apically. Such evenly tapered wall will be confluent with the access cavity, providing easy flow of irrigants during debridement and creates sufficient space for obturation of the radicular space. He also suggested that the root canal preparation should follow the original canal outline form. However attaining such a uniform tapered preparation is difficult to achieve because of variations in canal shape, presence of anatomic irregularities and canal curvature.

Historically, root canal instrumentation has involved the use of stainless steel hand files. Numerous investigations have shown that the preparation of curved root canals with stainless steel instruments frequently results in undesirable outcomes such as elbows, zips and canal transportation[7]. So to overcome these disadvantages NiTi instruments were introduced which greatly reduced the elbows, ledges and zipping, but the cutting efficiency of the tips of the rotary files lead to canal transportation. As the advancements of nickel-titanium rotary instruments over the years led to newer techniques and instrument designs came the introduction of safety tips or non cutting tips which greatly reduced canal transportation [21]. Root canals prepared by this nickel-titanium instruments showed increased canal cleaning ability less transportation, less canal straightening and perforation [44,31,32]. All these advantages of nickel- titanium instruments were made possible by the flexibility property, enhanced by special design features and taper which helps to prepare and maintain the natural canal shape and curvature[56].

Several preparation techniques are followed for adequate preparation of the root canal system. Even though each preparation follows different techniques and instruments, the basic goal remains the same. Various techniques for root canal preparation were introduced and modified over the years. Basically this can be divided into apico-coronal preparation and corono-apical preparation. Clem and Wein introduced step back technique or telescopic technique. This technique relies on reduction of working length stepwise for larger files (usually in 1 or 0.5mm steps) which result in a flared shape with 0.05 and 0.10 taper respectively. Incremental reduction of working length for stiffer and larger instruments reduced the forces associated with aberrant preparation especially in curved canals. However due to inherent stiffness of the larger size files this technique often resulted in iatrogenic damage to natural canal shape. Thus to overcome this drawback Marshall and Pappin in 1980 introduced crown-down pressure less technique[9]. This technique involves preparing the coronal part of the canal (canal orifice) first by using larger instruments and then progressively working down the root canal with smaller files. Pre-enlarging the orifice of the canal prior to completing apical preparation provides several advantages, those including straighter access to the apical region, minimize or eliminate the amount of necrotic debris that could be extruded through apical foramen during instrumentation, improved irrigant penetration and enhanced tactile control. Studies have shown that crown-down technique produce fewer canal blockages, less apically extruded debris, and a reduced incidence of apical transportation when compared to step-back technique. Later Abou Rass, Glick and Frank[26] introduced a method called "anticurvature filing" to prevent excessive dentin removal from the curvature of thin roots. In this technique a precurved hand file was used to file the canal away from the danger zone. Similarly, during the same time period Roane et al introduced "Balanced force technique" in 1985. This concept came with development of a newer file design the Flex -R files. Balanced force technique involves three steps [63]. First step is a passive clockwise rotation of 90° to engage dentin, then in the second step instrument is held in an axial direction with adequate pressure and rotated in a counter clockwise direction to break loose the engaged dentin. In the third step the file is removed with clock wise rotation. Advantages of this technique were that, it has got good canal centering ability. Disadvantage of this technique is that every time the file is removed from the canal it is more like a filing stroke which leads to some amount of straightening of the canal.

Regardless of what technique is used for canal preparation, apical enlargement and size of apical preparation play a major role in determining the success and failure of treatment. Apical portion of the root canal is important as it is the region more likely to harbour maximum intra radicular bacterial load and complicated anatomical ramifications which is usually associated with endodontic treatment failure[39]. In a study by Carlos et al, 46.8% of the samples collected from apical delta after chemo mechanical preparation showed bacteria and bacterial biofilm which caused failure of root canal treatment , this was was 3 times more than the coronal and middle third[17]. Therefore the aim of apical enlargement is to eliminate bacterial load directly or indirectly from this area of root canal system[13].

Two primary mechanical elements are to be considered while preparing apical area. They are apical width and endpoint of prepared shape in relation to the apical anatomy. The aim of apical widening is to fully prepare apical canal areas for maximum irrigation efficacy and optimum antimicrobial activity. Proper apical preparation aids in successful irrigant penetration and debridement. In many studies master apical file size had been related to initial file size. Historically the rule which is followed for master apical file size is "three size larger to the fist apical binding file"[38].

A study by Dulton et al showed, as the file size increases there will be reduction in remaining bacterial count and also increased risk of fracture due to reduction of canal wall thickness [58]. Studies by Akhlaghi et al[50] showed that for the proper penetration of irrigants for debridement and smear layer removal from the apical region, apical enlargement up to 25 size file is adequate if a suitable coronal taper is achieved. They concluded that it is unnecessary to remove dentine more than 25 size from the apical part of root canal which will weaken the root structure if adequate coronal taper is present. Taper of NiTi instruments is one of the property which is directly related to the shaping of the canals. Variation in file taper can affect the quality of canal shaping which in turn can affect the overall strength and longevity of the tooth[60].

Study by Askerbeyli Ors et al showed there will be increased stress concentration with an increase in taper[3] and Zandbiglari et al stated that the roots are significantly weakened as the root canals are prepared with instruments having greater taper [61]. As the remaining dentine thickness has got a direct relation to vertical root fracture the degree of taper of a prepared root canal could become a factor of resistance or reason for root fracture[61]. Nickel-titanium files with high degree of taper are thought to weaken the root especially in curved canals and canals with invaginated grooves[45,29].

One of the major objective of root canal instrumentation is to maintain the original canal anatomy and removing radicular dentine as less as possible so as not to weaken the root structure there by reducing the chance of vertical root fracture. Preservation of the radicular dentine or root canal wall thickness is essential for the strength and longevity of the endodontically treated teeth. Studies have shown direct relationship between remaining dentine thickness and possibility of root fracture in endodontically treated tooth.

Extensive literatures support to prove that, as the dentine cementum wall thickness decreases its ability to withstand stress concentration decreases which increase the chance of vertical root fracture and eventually lead to tooth loss. Trabert et al in 1978 studied the impact resistance of tooth to simulated trauma and showed the preservation of internal root structure i.e.; radicular dentine provided maximum resistance to fracture[54].

Literatures reports about predisposing and iatrogenic factors leading to vertical root fracture which include tooth structure loss due to caries, endodontic access cavity design and extensive root flaring[43]. As the amount of dentine removal increases the chances of endodontically treated teeth to fracture increases proportionally[54]. The other reasons for vertical root fracture in endodontically treated tooth includes restorative procedures after root canal therapy like dowel space preparation, improper dowel and traumatic sealing of intracanal restoration[51]. All this shows a direct relation between the remaining dentine thickness and strength of root[23, 15,49] and the importance of preservation of sound dentine [24].

Root canal treatment has long been criticized for weakening teeth, especially root which making them more prone to fracture. Earlier few investigators proposed endodontically treated root dentin was more brittle than normal vital tooth, but punch shear tests of endodontically treated tooth showed only 14% reduction in toughness in dentine compared to vital dentin in a study done by Carter et al[10]. Coronal fracture of most of the endodontically treated teeth can be attributed to loss of tooth structure caused during access cavity preparation[25]. Likewise root fracture of endodontically treated tooth are more due to excessive removal of root dentine which lead to weakening of root during cleaning and shaping . Any occlusal stress in coronal area is magnified in radicular area due to its small volume and cross sectional area. Studies done on fatigue life of dentine of young and old patients showed older patients had shorter fatigue life than younger patients[4]; suggesting fatigue of root over years may be responsible for root fracture in endodontically treated teeth in older patients. Reduction in remaining dentin thickness less than 1 mm jeopardize root integrity[22,9].

Thickness of remaining radicular dentin is directly related to the ability of teeth to withstand forces; therefore treatment that causes indiscriminate removal of tooth structure from the canal wall during endodontic treatment should be avoided. Even though the literature does not clearly suggest a minimum remaining dentin wall thickness, 0.3mm is considered as critical for remaining dentine wall thickness and [18] 0.5mm for dentine cementum wall thickness to resist vertical root fracture.

Other than remaining dentin wall thickness, curvature of canal, external root morphology, extent of canal enlargement and post placement are considered as predisposing factors which influence direction and location of vertical root fracture[19] in endodontically treated teeth[16]. A demographic analysis of vertical root fracture by Cohen indicated vertical root fractures are statistically more prevalent in maxillary premolars and mandibular molars[11]. Kishen in his study explained the mechanism and high risk factors which lead to fracture of endodontically treated teeth. He stated that loss of dentin compromises the integrity of remaining root structure. As the remaining dentine thickness decreases magnitude of tensile stress and stress concentration in the root increases which will lead to vertical root fracture[30]. Prevalence of vertical root fracture in endodontically treated tooth was studied by different authors and their findings were 10.9% [16] 12.9% [55] and 30.8% [48] of this 56% of vertical root fracture was seen in endodontically treated maxillary first premolar[53].

While performing root canal treatment the clinician's knowledge about number of roots and root canal morphology and its possible variations in different tooth is important. In spite of advancement in instrument designs and metallurgy root canal preparation is negatively influenced by anatomical variations[42]. Maxillary pre molars are frequent candidates for root canal treatment and account for almost 15.8% to 21.5% of all endodontically treated teeth[57,59]. Bifurcated maxillary first premolar has anatomical features that require consideration when performing endodontic treatment. The internal and external morphology of bifurcated maxillary first premolar has been studied over these years by different people using different techniques. Typically maxillary first premolar has two roots and two canals. Studies show prevalence of bifurcated root in maxillary first premolar as 61%[27]. An invagination on the palatal aspect of buccal root of maxillary first premolar is found in 80% - 100% of teeth [20,6,52] and has been named as furcal concavity, radicular grove, buccal furcation grove and developmental groove.

A morphometric study on Furcal groove in freshly extracted bifurcated maxillary premolar was first done by Tames et al[52]. They found the groove starting apical to furcation and reaching its maximum invagination at a mean depth of 0.4 mm at mean distance of 1.18mm away from the furcation and then becoming shallower gradually and travelling a mean distance of 5.38mm and disappearing near the apex. Tames et al calculated the minimum dentinal width at the deepest portion of invagination to be 0.81 mm. They also found out that as the location of bifurcation is more coronally the deepest portion of invagination is located more away from the furcation and vice versa.

Lammertyn et al examined 141 bifurcated maxillary first premolar and found furcal groove in 83% of the studied teeth. Mean depth of the groove was found to be 0.36 mm in coronal third, 0.34 mm in the middle third and 0.05 mm in the apical third[34].

Presence of furcation groove has its importance in endodontic, restorative and periodontal procedures. Length of the groove varies from 1.1 to 9.0 mm [2,35]. Groove starts apical to the furcation and reaches its maximum depth at a mean length of the groove and gradually extending superficially when groove reaches the apex[52]. Studies shows that average dentin wall thickness in the deepest invagination point of groove to be 0.78 to 1.18 mm [52,2,35,34,34,5].

Irregularities present on the external root surface can have an impact on the tensile stress; these irregularities might reduce the fracture resistance of tooth by exaggerating stress at the root surface in the furcal groove area of root canal[47]. Endodontic treatment can jeopardize this danger zone which can lead to vertical root fracture and strip perforation. Remaining dentin wall thickness, concavity on external root and radius of curvature together in lingual aspect of buccal root of maxillary first premolar make it more susceptible to fracture in an unpredictable manner[47].

In this study a limited field CBCT evaluation of dentine cementum wall thickness at deepest portion in radicular groove of bifurcated maxillary first premolar was done before and after instrumentation. Only few studies have attempted to assess the quantity of remaining dentin cementum wall thickness at the deepest portion of the furcation groove and compare it with proposed minimum 0.5mm dentine cementum wall thickness which was stated by McCann et al, although it was in contrast to 0.3 mm remaining dentin thickness proposed by Lim and Stock which did not consider the inclusion of cementum layer. Microscopic study of root apices by Katz et al in two different age groups (young and old) showed difference in cementum deposition depending on age[28]. There is no study done to find out the cementum thickness in root. In this study the decision to keep 0.5 mm as minimum canal wall thickness required after instrumentation proved to be a reasonable choice as it include cementum layer also.

Morphological study previously done by Tames et al showed the mean dentine cementum wall thickness of entire furcation groove to be 0.81 mm and the thinnest portion was located in the mid groove area[52]. Study by Ziago et al showed mean pre dentine cementum wall thickness at coronal, middle and apical portion of furcation groove did not exceed 0.73 mm and the thinnest portion was at the mid groove area[62]. Both this studies confirmed the thinnest dentine cementum wall is present in the mid grove area. So in this study we considered mid groove area as the deepest portion of invagination of furcation groove and assumed that as the thinnest point of dentine cementum wall.

Taking in to account of studies by Studies by Akhlaghi et al [50] it was decided to limit the apical preparation size to 30, which will ensure proper penetration of irrigants to remove debris and smear layer from the apical region.

In order to study the efficiency of instruments and techniques developed for root canal preparation, a number of methods have been used to evaluate remaining canal wall thickness before and after preparation. Radiographs were used as one of the methods for assessment. Advantage of this method is that no physical intervention is required. But it only gives a two-dimensional image and cross-sectional assessment of the root canal is impossible[23,14]. Another method is the “Serial Sectioning Technique”. This technique allows comparison of pre and post instrumented canals, but a difficult set-up and physical sectioning of the teeth is required which results in unknown tissue changes and loss of tooth structure. All these methods will lead to inaccurate reading for pre and post instrumented specimens. As a result, information acquired by using these methods could be misleading.

In order to overcome these drawbacks non destructive methods were advocated which will increase the accuracy of the results. With fast growing technological advances, the demand is for non-destructive methods that would give precise information about root canal morphology and canal preparation. Few such techniques include computed tomography, spiral C T, cone beam computed tomography etc which can give reproducible three dimensional images for the evaluation of the external and internal morphology of the tooth.

In this study it was decided to use CBCT as it is a non-destructive evaluation method for both external and internal morphology of tooth[41,12]. We used a CS 9300 limited field cone beam computed tomography (CBCT) machine, keeping slice thickness as 90 micrometers as it is the smallest measurable width possible in this machine. We set the field of view as 5 cm in diameter and 5 cm in height. Carestream software was used for both pre and post instrumentation image assesment as it is more precise in diagnosis with low dose and high image resolution. Another important advantage of CBCT is its ability to measure pre and post instrumentation canal wall thickness. This feature is of utmost importance, as it can keep a constant control (initial canal wall thickness) over which each successive instrumented canal can be compared and analysed following subsequent scanning which is an excellent way to examine root canal wall thickness in a non destructive manner following instrumentation [40].

Furthermore the use of CBCT in these type of studies appears to be superior to other techniques because it affords a virtual in situ image and also physical cross sectioning of root which invariably results in loss of 0.4 mm or more of root structure is avoided in each horizontal slices, thereby avoiding error in post instrumentation data[1,7]. Measurement of distance on images was evaluated by Kobayashi et al by CBCT and the results by his study indicated CBCT gives more accurate measurements than spiral computerized tomography in measuring distance between points[33].

In this study we analysed furcal groove in buccal root of 99 bifurcated maxillary first premolars to find the minimum dentine cementum wall thickness at the thinnest portion using Limited Field CBCT before and after instrumentation with three different techniques and three different files. The three different files used were

1.Stainless steel hand files with 2% taper which were used in step back technique.

2. Neoendo Nickel-titanium files with increasing (changing) taper which were used in rotary motion.

3. WaveOne single file system which was used in a reciprocating motion.

Pre-instrumentation dentine cementum wall thickness was measured at the mid groove area, considering it as the thinnest portion of canal wall in furcation grove. In the present study the mean pre-instrumentation dentine cementum wall thickness for 99 teeth at mid groove area was found to be 0.87 mm. Post instrumentation measurements showed group III which used WaveOne file removed a mean of 0.24 mm of radicular dentine, where as group I which used stainless steel K file removed 0.154 and group II Neoendo files removed only 0.148 mm of dentine only. The mean post instrumentation thickness of the dentine cementum wall at mid-groove area is 0.73 mm for stainless steel K file group, 0.74 mm for Neoendo group and 0.61 mm in WaveOne group. Statistically there was a significant difference in mean thickness of the stainless steel k file group (0.73 mm) and Neoendo group (0.74 mm) with WaveOne group (0.61 mm). Pair wise comparison between each groups and the significance between each group was analyzed. When comparing between group I and group II there is no significant difference, but when group I is compared with group III it showed statistically significant at level five. Comparison of group II and group III showed statistical significant at level one.

Study by Sarao et al showed that the thinnest portion of the canal wall is not present at the deepest portion of furcal groove instead at the mid groove region. They measured canal wall thickness at three points in furcal groove i.e.; coronal, middle and apical portion of the groove and found out the thinnest portion comes at the mid groove area [46]. According to his study the average distance of deepest invagination from the furcation was 1.15 mm, which was close to the measurement of 1.18 mm by Tamse et al. To date there is no study conducted to measure the distance from the furcation to the deepest portion of invagination of groove.

In the present study the mean pre-instrumentation dentine cementum wall thickness for 99 teeth at mid groove area was found to be 0.87 mm which was different from other studies. Lammertyne et al did an anatomical study on the furcal groove of bifurcated maxillary premolar. They measured the remaining dentinal thickness at a level of 2 mm from the apex to the furcation and found it as 1.17 mm[34]. Kartz et al found the mean radicular dentinal thickness of bifurcated maxillary premolar to be 0.99mm at 6 mm coronal to the apex[28]. Bellucci and Perrinni et al found remaining dentinal wall thickness to be 0.98 mm at a level midway between the CEJ and 4 mm coronal to apex[5]. Likewise Ziago et al found out the remaining dentinal thickness to be 0.73 mm at 0.5 mm apical to the point of initiation of the groove[62].

The variations in thickness found in our study and other studies can be due to the difference in the corono-apical level where the measurements were made, it can be also because of the difference in the imaging methods.

Lammertyn et al used profile projector whereas Kartz et al used digitizer to take measurements on a photograph. Bellucci and Perrini used optical microscope while Ziago et al used CBCT.

In this study the mean pre instrumentation remaining dentin cementum wall thickness at the deepest portion of invagination was 0.87 which is almost similar to the morphometric study by Tamse et al which showed 0.81 mm as the remaining dentinal thickness at the deepest portion of invagination of furcal groove[52].

Likewise the pre-instrumentation dentin cementum wall thickness in this study was calculated at mid groove area (0.87mm). Studies by different authors also showed similar findings with thinnest canal wall thickness at this point. Study by Kartz et al showed 0.78 mm[28] and by Ziago et al showed 0.83 mm remaining dentin wall thickness in the mid-groove area.

The mean post instrumentation thickness of the dentine cementum wall at mid-groove area is 0.73 mm for stainless steel K file group, 0.74 mm for Neoendo group and 0.61 mm in WaveOne group. Post- instrumentation, there was a significant difference in mean thickness of the stainless steel k file group (0.73 mm) and Neoendo group (0.74 mm) with WaveOne group (0.61 mm).

The first important finding in this study was the significant difference in mean dentine removed by WaveOne than other two groups. WaveOne removes 0.245 mm dentine whereas 0.154 mm dentine was removed by stainless sell K file and 0.148 mm by Neoendo file. The confidence interval is more around the mean in WaveOne group. By these results it is suggested that Neoendo files removed more predictable and less amount of dentine especially in the critical zone of deepest portion of the grooves invagination as compared to stainless steel K file and WaveOne.

Second finding in this study was the effect of instrument size on thickness of dentine removal. It was assumed that instruments with less taper removed less amount of dentine than the larger tapered instruments. However according to the results of this study 4% tapered Neoendo files showed less dentine removal than 2% tapered stainless steel K files.

Third finding in this study was the mean dentine cementum wall thickness of all groups post instrumentation is less than 1mm and more than 0.5 mm which was considered as critical.

Further research is needed in this aspect to determine or define the parameters for dentine removal and subsequently establish a minimal value of dentine cementum wall thickness. For the clinician it will be of immense help if the minimum dentine cementum wall thickness required to resist root fracture is known. Earlier studies had made recommendations only based on assumption regarding the minimum thickness without any support of research. These unsupported assumptions and recommendations are seen both in endodontics and prosthodontics literatures suggesting the minimum thickness from 0.3 mm to 1.0 mm.

Literature by Lim and stock[18] tried to establish a minimum remaining dentine wall thickness and speculatively kept it as 0.3 mm. McCann et al in his study on mesial root of mandibular first molar speculatively kept 0.5 mm as minimum residual wall thickness to prevent strip perforation [37]. While Pilo et al kept 1 mm as minimum thickness for bifurcated maxillary premolars after root canal and conservative post space preparation [43]. All tooth used in this study showed less than 1 mm of dentine cementum wall thickness after instrumentation.

On the basis of literature reviews and the results from our study, it can be stated that mechanical preparation of bifurcated maxillary premolar results in thinning of root canal walls below the critical zone of 1 mm which is essential in maintaining the integrity of root structure. Recent study by Kim et al using 3D finite elemental analysis showed the instruments with greater taper shaft had stress values that generate more stress in root dentin which eventually lead to vertical root fracture[29]. Further researches and efforts are needed in the direction of developing newer techniques and instrument designs that preserves the radicular tooth structure.

Micro-computed tomography (μCT) delivers high quality images and is designed to be used exclusively for bench-top research, compared to the limited field CBCT machine that is primarily for clinical use. In the present study, micro-computed tomography could have provided better image quality, which potentially may have increased the accuracy of the data collected [41,36]. Micro-computed tomography is specifically designed for *in vitro* imaging of extracted teeth which limits their use to lab based studies. An advantage of micro-computed tomography technology in comparison to the limited field CBCT technology is its ability to superimpose pre-instrumentation and post-instrumentation images of a canal. This three dimensional feature is especially useful when comparing dentin removal relative to an area which poses an anatomical risk such as the furcation groove in BMFPs. The significant cost of micro-computed tomography restricts their use. Future research should be directed to repeat a similar study using a μCT and benefiting from its advantages.

Summary

SUMMARY

The purpose of the study was to conduct a morphometric analysis on the buccal furcation groove in extracted bifurcated maxillary first premolars (MFPs) and to correlate anatomical measurements using CBCT before and after cleaning and shaping using three file systems - stainless steel K files, NeoEndo files and Wave One file.

In this invitro study 99 extracted human bifurcated maxillary first premolars were selected. Preliminary CBCT scan was done with CS 9300 limited field cone beam computed tomography (CBCT) machine. Pre-instrumentation dentine cementum wall thickness was measured at the mid groove area, considering it as the thinnest portion of canal wall in furcation grove. Access cavity preparation was done using Endo access bur in all the samples. The teeth were then randomly divided into three groups, 33 teeth in each group.

First group was instrumented with Stainless steel (SS) K-file up to apical 25 size, 2% taper. Second group with Neoendo flex file (NF) up to apical 25 size, 4% taper. Third group with WaveOne (WO) primary file 25 size, 8% taper. Working length was verified using a periapical radiograph. Canals glide path was established using size #15k file. Canal irrigation was achieved with 5.25% sodium hypochlorite during instrumentation and delivered into the canal by a 5 ml syringe with a 27 gauge side vented needle. In group I all teeth were instrumented using stainless steel K file to an apical

size #25 in step back technique. In group II Neoendo flex files was used sequentially till size 0.04/#25. In group III WaveOne files 0.08/ #25was used. After completing the instrumentation, the samples were subjected to post operative CBCT scan. Dentine cementum wall thickness at same point was measured and noted. The values were subjected to statistical analysis - one way ANOVA, Post Hoc HSD test and paired sample T test.

Post instrumentation measurements showed group III which used WaveOne file, removed more dentine than the other two groups. The mean post instrumentation thickness of the dentine cementum wall at mid-groove area is 0.73 mm for stainless steel K file group, 0.74 mm for Neoendo group and 0.61 mm in WaveOne group. Statistically there was significant difference in mean thickness of the stainless steel k file group (0.73 mm) and Neoendo group (0.74 mm) when compared with WaveOne group (0.61 mm). Pair wise comparison between each groups showed no significant difference between group I and group II. Whereas when group I is compared with group III it showed statistically significant at level five and comparison of group II and group III showed statistical significant at level one. Findings of this study showed WaveOne file removed greatest amount of dentine where as Neoendo files removed a more predictable and consistent thickness of dentin along the length of buccal root of BMFP, irrespective of the pre instrumentation thickness of dentin when compared to the K file and WaveOne files that remove a more variable thickness of dentin. All the instrumented canals showed remaining dentine cementum wall thickness less than 1 mm and above 0.5 mm at mid groove area which is considered as critical.

Conclusion

CONCLUSION

1. The thickness of dentin removed from the buccal root of BMFPs in the area of furcation groove after instrumentation with three different files showed WaveOne removing greatest amount of dentine (0.24 mm) followed by stainless steel file (0.154 mm) and the least by Neoendo file (0.148 mm)
2. Neoendo files removed a more predictable and consistent thickness of dentin along the length of bifurcated buccal root of BMFP, irrespective of the pre instrumentation thickness of dentin when compared to the K file and Waveone files that removed more dentin.
3. All the instrumented canals showed remaining DCW thickness less than 1 mm and above 0.5 mm at mid groove area which is considered as critical.

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Annexures

ANNEXURE –I

RAGAS DENTAL COLLEGE & HOSPITAL
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TO WHOMSOEVER IT MAY CONCERN

Date: 6.1.2018

Place: Chennai

From
The Institutional Review Board,
Ragas Dental College & Hospital,
Uthandi,
Chennai – 600119.

The dissertation topic titled **"CBCT EVALUATION OF DEEPEST PORTION OF FURCAL GROOVE IN MAXILLARY FIRST PREMOLARS BEFORE AND AFTER INSTRUMENTATION WITH STAINLESS STEEL HAND FILES AND TWO NiTi ROTARY FILE SYSTEMS"** submitted by **Dr. ASHOK JACOB ABRAHAM** has been approved by the Institutional Review Board of Ragas Dental College & Hospital.

Dr. N.S. AZHAGARASAN, M.D.S.,
Member Secretary,
Institutional Review Board,
Ragas Dental College & Hospital,
Uthandi,
Chennai – 600 119.

RAGAS DENTAL COLLEGE Chennai

ANNEXURE –II

URKUND

Urkund Analysis Result

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Submitted: 1/8/2018 5:53:00 PM
Submitted By: ashokjaco@gmail.com
Significance: 3 %

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