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Evaluation of the cleaning efficiency of the isthmus using different rotary instrumentation techniques

(In vitro study)

A thesis

Submitted to the council of the College of Dentistry at the University of Baghdad, in partial fulfillment of the requirements for the degree of Master of Science in Conservative Dentistry

By

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بسم الله الرحمن الرحيم

{وَقُلْ رَبِّ زِدْنِي عِلْمًا}

صدق الله العلي العظيم

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Declaration

I certify that the organization and preparation of this thesis “Evaluation of the cleaning efficiency of the isthmus using different rotary instrumentation techniques”(in vitro study) have been made by the graduate student Zuha Ayad Jaber , under my supervision in the college of Dentistry , University of Baghdad ,in partial fulfillment of the requirements for the degree of Master of Science in Conservative Dentistry .

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We, the member of the Examining Committee, certify that after reading the thesis Evaluation of the cleaning efficiency of the isthmus using different rotary instrumentation techniques (In vitro study) and examining the student Zuha Ayad Jaber in its contents, we think it is adequate for the award of the degree of master of science in conservative dentistry.

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Dedication

To my wonderful parents

To my brother and sisters

To my supportive husband

To my lovely children

Ali & Lamar

Abstract

The aims of the study were to evaluate the unclean/clean root canal surface areas with a histopathological cross section view of the root canal and the isthmus and to evaluate the efficiency of instrumentation to the isthmus using different rotary instrumentation techniques.

-The mesial roots of thirty human mandibular molars were divided into six groups, each group was composed of five roots (10 root canals) . Group one A: prepared by Protaper system to size F2 and irrigated by hypodermic syringe, Group one B: prepared by Protaper system to size F2 and irrigated by endoactivator system, Group two A: prepared by Wave One small then primary file and irrigated by hypodermic syringe, Group two B: prepared by Wave One small then primary file and irrigated by endoactivator system, Group three A: prepared by step back technique to size 25 file as master apical file and irrigated by hypodermic syringe, Group threeB: prepared by step back technique to size 25 file as master apical file and irrigated by endoactivator system . All the roots were sectioned at 2mm, 6mm ,12mm from the apex and studied by histopathological cross section. The degree of cleaning of each section was measured by the use of Autocade 2004 software system.

- The result of least uncleaned isthmus surface area at coronal, middle and apical section was found by the Protaper system with endoactivator which represented the mean of the percentage of uncleaned surface area of 16.87%, 14.32% and 9.55% respectively**.** Then Wave One system with endoactivator and then the other systems. The system that produced least uncleaned canal wall was by Protaper system with endoactivator at coronal ,middle ,and apical sections of 12.21%, 9.14% and 18.55% respectively , followed by Wave One with endoactivator and then the other systems. The mean of highest percentage of

increased canal diameter which was Protaper system, Wave One system and then step back. The comparison between the groups in the means which showed that the highest percentage of decrease in isthmus area was with the Protaper system, Wave One system and lastly the step back.

-The Protaper system with endoactivator was the best system in canal and isthmus cleaning.

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List of abbreviations

ANOVA	Analysis of variance test
CFUs	Colony forming units
D	Diameter
EDTA	Ethylene Diamine Tetraacitic Acid
F-test	Fissure Test
GT	Greater Taper
H&E	Hematoxylin and Eosin
ISO	International Standard Organization
LSD	Least Significant Difference
MAF	Master apical file
μm	micro Milliliter
micro-CT	Micro-Computed Tomography
ml	Milliliter
Mm	Millimeter
Ncm	Newton centimeter
NiTi	Nickel-Titanium
P -value	Probability value
RDT	Residual Dentine Thickness
rpm	Revolution per minute
SEM	Scanning Electron Microscopy
SAF	Self-Adjusting File
SD	Stander deviation
S.E	Stander Error
SMI	Structure Model Index
USB	Universal Serial Bus

Introduction

Canal debridement is the removal of existing or potential irritants from the root canal system. These irritants consist of either singly or in combination: bacteria, bacterial byproducts, necrotic tissue, organic debris, vital tissue, salivary byproducts, hemorrhage, and other contaminants.

The components in a necrotic pulp space represent a potent irritant .The principle of debridement is simple. Ideally, instruments contact and plane all walls to loosen debris. The chemical action of irrigants further dissolves organic remnants and destroys microorganisms. Irrigants then flush the loosened and suspended debris from the canal space. This rids the canal space of irritants **(Richard and Mahmoud, 2002).**

Mechanical instrumentation is one of the important contributors to bacterial reduction in the infected root canal .The aim of root canal preparation with rotary instruments is to produce a gradual tapering shape in the bulk of the root canal system, with the narrowest diameter apically, the greatest diameter coronally and a smooth flow between the two. The apical preparation must be at least an ISO size 25 to allow better irrigant penetration **(Pitt Ford et al, 2002).**

Instrumentation of the root canal system must always be supported by an irrigation capable of removing pulp tissue remnants and other loose material. The efficacy of an irrigation delivery system is dependent not only on its ability to deliver the irrigant to the apical and noninstrumented regions of the canal space and to create a current strong enough to carry the debris away from the canal systems but also on the ability of the irrigating solutions to dissolve both organic and inorganic matter **(Boutsioukis et al,2009; Sedgley etal,2005).**

Roots with multiple canals have the potential to have more complicated root canal systems. An isthmus may exist between two root canals in the same root. This isthmus connection becomes an important factor in the ability to thoroughly clean and débride these root canal systems**.**

If an isthmus exists and is not included in the root-end preparation, the remaining necrotic pulp tissue and debris may be a nidus for recurrent infection and subsequent treatment failure. **(Ingle and Backland, 2002).**

Recent advances in instrumentation and irrigation have improved the ability to debride canals, but it is still not possible to remove all debris. Inadequate canal debridement can lead to a decrease in endodontic success **(Siqueira, 2001).**

Aims of the study

1. To evaluate the clean/unclean root canal surface areas by a histopathological cross section view for:

a) The root canal.
b) The isthmus area.

2. To evaluate the efficiency of instrumentation to the isthmus area in the orifice region using different rotary instrumentation techniques.

Review of literature

1. Introduction

The root canal system of a tooth is often extremely complex and it is difficult to disinfect completely and quickly. It may be that the best attempts of the operator just to reduce the residual bacterial load to a non-pathogenic number, or change the resident flora sufficiently to allow periapical healing.

These microbes and their byproducts can be removed by a combination of mechanical and chemical means. Mechanical removal relies on the ability of the operator to remove infected pulp and dentine from the surfaces of the root canal by planning the walls; infected material in the lumen of the root canal will be removed **(Pitt Ford et al, 2002).**

Schilder' defined the general objectives of canal preparation as follows: "Root canal systems must be cleaned and shaped: cleaned of their organic remnants and shaped to receive a three dimensional hermetic filling of the entire root canal space **(Schilder,1974) .**

The mechanical objectives for cleaning and shaping are:

1. A continuously tapering preparation the canal preparation must flow and progressively narrow in an apical direction.

2. Original anatomy maintained canal systems move through multiple geometric planes and curve significantly more than the roots that harbor them. Additionally, external root concavities must always be considered so that the clinician can file away from danger, removing necessary amounts of dentin to ensure cleaning but maximizing residual circumferential dentine, especially on the furcal side of multirooted teeth.

3. Position of the foramen maintained enlarging the apical foramen (or foramina) without relocating or losing its position is essential.

4. Foramen as small as is practical keeping the apical foramen as small as is practical to permit three-dimensional obturation **(Stephen et al, 2002).**

1.1 Canal configuration

The canal configurations were categorized using Vertucci's classification as follows:

(1)Type I. A single canal extends from the pulp chamber to the apex.

(2)Type II. Two separate canals leave the pulp chamber and join short of the apex to form one canal.

(3)Type III. One canal leaves the pulp chamber, divides into two within the root, and then merges to exit as one canal.

(4)Type IV. Two separate and distinct canals extend from the pulp chamber to the apex.

(5)Type V. One canal leaves the pulp chamber and divides short of the apex into two separate and distinct canals with separate apical foramina.

(6)Type VI. Two separate canals leave the pulp chamber, merge in the body of the root, and redivide short of the apex to exit as two distinct canals.

(7)Type VII. One canal leaves the pulp chamber, divides and then rejoins within the body of the root, and finally redivides into two distinct canals short of the apex.

(8)Type VIII. Three separate and distinct canals extend from the pulp chamber to the apex **(Vertucci ,1984).**

-Weine classified root canal anatomy into 3 types.

(1) Type I: One canal with one orifice and one apical foramen .
(2) Type II: Two canals that merge into one and exit as one canal.
(3) Type III: One canal that divides into two and exit as two canals.

- Also canal configurations were categorized by Ingle classification as follows:

(1)Type I. A single canal extends from the pulp chamber to the apex.

(2)Type II. Two separate canals leave the pulp chamber and join short of the apex to form one canal.
(3)Type III. One canal leaves the pulp chamber, divides into two within the root, and then merges to exit as one canal.
(4)Type IV. One canal leaves the pulp chamber and divides short of the apex into two separate and distinct canals with separate apical foramina.

1.2 Anatomy of the mandibular first molar

1.2.1 Buccolingual Section

The buccolingual cross section of the mandibular first molar figure (1-1) demonstrates a large pulp chamber that may extend well down into the root formation. The mesial root usually has a more complicated root canal system because of the presence of two canals. The distal root usually has one large canal, but two canals are often present. Occasionally, a fourth canal is present that has its own separate root.The pulp horns are evident in most mandibular first molars. The pulp chambers of the mesial roots are square to rectangular (excluding the pulp horns), but this configuration is not seen in a root with a single canal. One or both of the mesial canals may be curved, to different degrees , or relatively straight. The two canals may join each other in the apical region to exit in a common foramen, or they may have separated apical foramina **(Stanley , 2010)**.

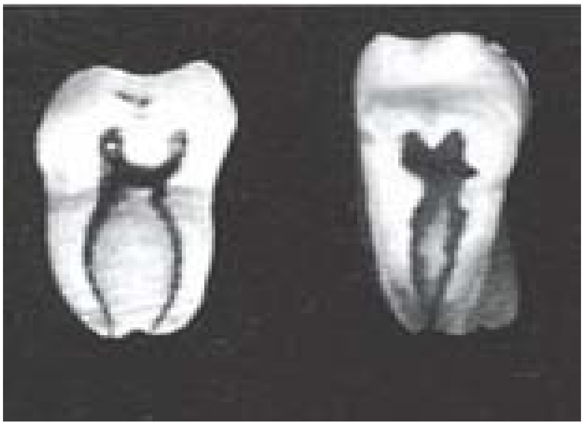


Figure (1-1) Buccolingual Section.

The apical foramen usually appears to exit on the tip of the broad mesial root, but in some roots one of the two canals exits on the side of the root tip. The diameter of the mesial canals is usually very small and shows a slight taper.The distal root usually has one large pulp chamber, which is very wide in the buccolingual dimension, whereas other distal roots may possess a pulp chamber that is more constricted. The distal root usually has one large pulp canal, which may show a wide buccolingual dimension until the canal constricts a few millimeters from the apex of the root. When two canals are present, they will be partially or completely separated by a dentinal tissue. The apical foramen of a root with a single canal usually appears at the apex of the root, but it may be slightly buccal or lingual to the apex of the root **(Stanley , 2010).**

1.2.2 Mesiodistal Section

The mesiodistal section of the mandibular first molar figure (1-2) has minor variations in the pulp chamber or canals' form. The mesial and distal pulp cavities have canals and chambers that are centered within the roots and crowns. The pulp horns may be prominent to undetectable, or may demonstrate a combination of these variations.The pulp chambers are usually rectangular (excluding the pulp horns) and their size depends on secondary and reparative dentin formation **(Stanley , 2010).**

Figure (1-2) Mesiodistal Section.

The mesial root and canals usually show considerable curvature. Some canals demonstrate less curvature. The apical foramen usually appears to exit at the tip of the root but may appear to exit on the mesial or on the distal aspect of the root.The distal root is usually straighter and seems to be a little shorter than the curved mesial root. The distal canal is usually larger than the mesial canal, but the canals may look very similar in size when viewed from the buccal aspect. The distal canal usually tapers smoothly to the apical constriction. The apical foramen most often appears to be located on the distal aspect of the root **(Stanley , 2010)** .

1.2.3 Cervical cross section

The cervical cross section of the mandibular first molar figure (1-3)is generally quadrilateral in form. Distally, it tapers a little from the wider buccolingual measurement of the mesial aspect of the tooth. The pulp chamber outline mostly follows that of the root but may show buccal and/or lingual projections of dentin if the pulp chamber is excessively narrowed by secondary or reactive osteodentin **(Stanley , 2010).**

The pulp chamber floor has two small funnel-shaped openings into the mesial root (one buccal and one lingual). The distal aspect of the pulp chamber usually shows a single opening that is less constricted **(Stanley , 2010).**

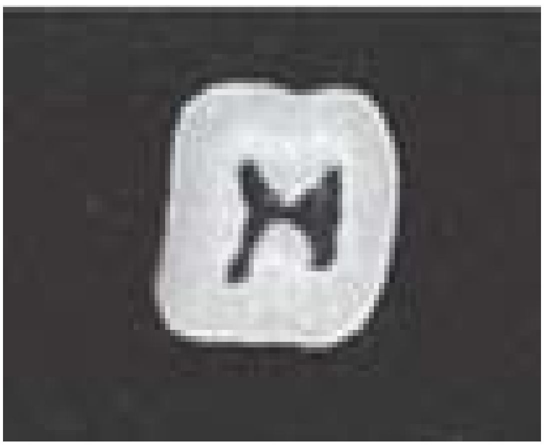


Figure (1-3) Cervical cross section.

1.2.4 Midroot cross section

The midroot view of the mandibular molar figure(1-1) usually demonstrates the root canal form, which resemles the major form of this tooth.The mesial root usually is somewhat kidney-shaped**,** with two separate canals, but a figure-eight shape of the root is also very common. The two canals may be totally separate, or one may be attached with the other canal. Even three canals may be found in this root on occasion **(Stanley , 2010).**

The distal root is usually rounder than the mesial root. Any circular root tends to be one root, whereas the wider distal roots buccolingually tend to have two canals. Even in a root with a single canal, the distal canal tends to show a developmental depression or concavity on the mesial aspect of the root **(Stanley , 2010).**

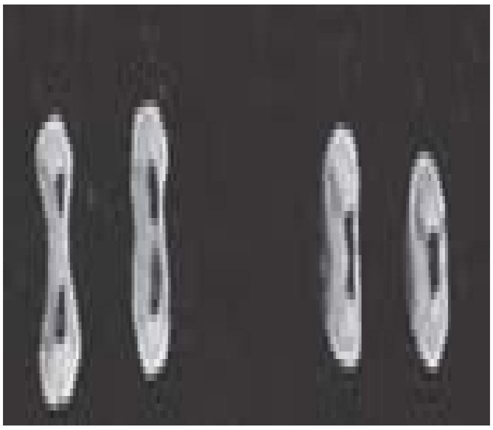


Figure (1-4)Midroot cross section.

1.3 The isthmus

It is a narrow connection between two root canals usually containing pulp tissue. The isthmus was called a "corridor" by Green in (1973) also called "lateral connection" by Pineda in 1973 and an anastomosis by Vertucci in 1984. In many teeth with a fused root there is a weblike connection between two canals called an isthmus, which can be either complete or incomplete **(Stephen et al, 2002).**

An isthmus is formed when an individual root projection is unable to close by itself. Partial or no fusion of root projections results in formation of root canals with isthmus in between. In clinical practice, this isthmus is important in the surgical and non surgical endodontic procedures. In both cases, it can lead to failure because of poor accessibility to root canal instruments, acts as bacterial reservoir and may reduce the success rate **(Teixeira et al. ,2003).**

The prevalence of isthmi in the mesial root of mandibular molars has been observed in previous studies **(Skidmore & Bjørndal ,1971; Cambruzzi & Marshall, 1983; Vertucci ,1984; Hsu & Kim, 1997; Von Arx ,2005)** in which observations were performed using different methods and at varying distances from the apex. Several classification systems of isthmus had been advocated. Hsu and Kim in (1997) are the most acceptable which is classified as type I if either two or three canals were present with no notable communication, type II if a definite connection was present between the two main canals. Type III was differentiated from type II by the presence of three canals with a connection between them. Incomplete a C shape with three canals are also included in this category. Canals extending to the isthmus area were classified as type IV. Type V was recognized as a true connection or corridor throughout the section
(Manisha and Kiran, 2010).

Teixeira , etal in (2003) investigated in vitro the incidence and position of the root canal isthmus in extracted mesiobuccal roots of maxillary and mesial roots of mandibular first molars. The isthmus incidence was greatest 3-5 mm from the apex. In teeth having two canals, a complete or partial isthmus was frequently observed in the sections between 3 and 4 mm from the apex. Of the isthmi present, 22% were complete and 37% partial in mandibular molars and 17.3% were complete and 11.7% partial in maxillary molars. They found that incidence of isthmus in the mesiobuccal root of the maxillary first molars and in the mesial root of the mandibular first molars was high, particularly in sections 3-5 mm from the apex. They concluded that cleaning the isthmus is a major challenge during root canal treatment.

Mannocci etal., in (2005) investigated the prevalence of root canal isthmi in the apical 5 mm of the mesial root of mandibular molars by means of micro-computed tomography (MCT) and describe the morphology of the isthmi. Isthmi were found to be present at all levels with prevalence figures between 17.25 and 50.25%. It was found that sections in the first millimetre from the apex had fewer isthmi than expected and that sections in the third millimetre from the apex, they found that Isthmi were present in the vast majority of roots observed. The third millimetre from the apex showed more isthmi than expected. The results of clinical and surgical endodontic procedures performed in the mesial root of mandibular molars may be affected by this aspect of the root canal anatomy.

Gu etal., in (2009) investigated the prevalence and configuration of the isthmi in the apical 6 mm of the mesial and distal roots of Chinese mandibular first molar by means of micro-computed tomography. The mesial roots of human mandibular first molars had a high incidence of isthmus. The isthmus incidence was greatest 4-6 mm from the apex in human mandibular first molar, with prevalence figures of 49.5%-66.1% and 17.3%-17.8% in mesial and distal roots, respectively. Gu ,et al concluded that the mesial roots of human mandibular first molars have a high incidence of isthmus, which may have clinical implications especially when surgical endodontics is performed on the mesial roots of mandibular molars.

Fan etal., in (2010)investigated the three-dimensional (3-D) morphology of isthmi in the mesial roots of mandibular molars. The incidence of an isthmus in the apical 5 mm of the mesial roots was 85% . Mandibular first molars had more isthmi with separate type and mixed type, whereas Mandibular second molars had more isthmi with sheet connections. They concluded that ,mandibular first molars present different anatomical features of isthmi in the apical part of the mesial roots than Mandibular second molars.

Manisha and Kiran, in (2010) investigated invitro the incidence and position of root canal isthmi in the apical 5 mm of the mesial root of mandibular first molars by means of high resolution spiral computed tomography (SCT) and described the morphology of the isthmi . Isthmi were found to be present at all levels with prevalence figures between 18.25 and 50.25%. A significant difference was found in the distribution of isthmi within section and it was found that sections in the third millimetre from the apex had more isthmi. They concluded that the incidence of root canal isthmus in the mesial root of the mandibular first molars was high , particularly in the apical 3-5 mm from the apex, and cleaning the isthmus was a major challenge during root canal treatment. The results of clinical and surgical endodontic procedures performed in the mesial root of mandibular molars might be affected by this aspect of the root canal anatomy.

1.3.1. Isthmus Preparation

Gencoglu and Gundogar in (2008) investigated the effect of ultrasonic debridement on cleaning effect of isthmus in mesial canals of mandibular first molars. They concluded that Usage of ultrasonic instruments was found to be effective in cleaning isthmus in mesial canals of mandibular first molar .

Matthew et al, in (2012) compared the effectiveness of debris removal between the Self-Adjusting File (SAF), WaveOne, and K3 file systems in the mesial roots of mandibular molars. In addition, the SAF was tested as a potential adjunct after instrumentation with other systems. They found that no significant difference in canal cleanliness among the groups, but the WaveOne was significantly worse for isthmus cleanliness .Use of the SAF as an adjunct only significantly improved canal cleanliness in the K3 group at the 2-mm level by an percentage of 1.7%. They concluded that no difference in canal cleanliness between the three file systems; however, the SAF and K3 files performed significantly better than the WaveOne with respect to isthmus cleanliness. When used as a final irrigation adjunct device after instrumentation, the SAF provided a significant improvement only in a subset of the K3 group.

Unni Endal etal., in (2011) conducted astudy in which a three-dimensional analysis of the isthmus area of the mesiobuccal root canal system in mandibular molars using high-resolution micro–computed tomography (m-CT) scanning and measured the amount of debris and root filling material in the isthmus after instrumentation/irrigation and root filling. Of the seven mesial roots, two had isthmus/anastomoses somewhere along its length in the apical 5 mm, and five had an isthmus that was continuous all the way from the coronal part to the apical part. The average percentage of isthmus surface area and isthmus volume after instrumentation was 21.4% and 9.4% of the whole root canal system, respectively. About 35.2% of the isthmus volume was filled with hard tissue debris after instrumentation/ irrigation. The average percentage of volume of filling material in the isthmus areas was significantly lower (57.5%) than in the main root canals (98.5%). They concluded that a considerable amount of dentin debris is produced and packed into the isthmus area during rotary instrumentation of mesial canals of lower molars despite continuous irrigation during and after instrumentation. The debris may partly prevent penetration of the filling material and sealer into the isthmus area.

1.4 Root canal preparation

1.4.1 Single File instrumentation techniques-Wave-One system:

In this system only 1 file is generally used to fully shape most of the canals. However, there are 3 Wave-One files available to effectively address teeth with wide range of an endodontic anatomy .The 3 Wave-One instruments are termed small (yellow 21/06), primary (red 25/08), and large (black 40/08) **(Clifford, 2012)**.

The Small 21/06 file has a fixed taper of 6% over its active portion. The Primary 25/08 and the large 40/08 Wave-One files have fixed tapers of 8% from D1-D3, whereas from D4-D16, they have a unique progressively decreasing percentage tapered design.

This design serves to improve flexibility and conserve remaining dentin in the coronal two-thirds of the finished preparation. Another unique design feature of the Wave-One files is that they have a reverse helix and 2 distinct cross-sections along the length of their active portions. From D1-D8, the Wave-One files have a modified convex triangular cross section figure(1-5), whereas from D9-D16, these files have a convex triangular cross-section figure(1-6). The design of the 2 Wave-One crosssections is further enhanced by a changing pitch and helical angle along their active portions. The Wave-One files have non cutting modified guiding tips, which enable these files to safely progress through virtually any secured canal. These design features enhance safety and efficiency when shaping canals that have a confirmed, smooth, and reproducible glide path **(Clifford, 2012).**

Fig (1-5)WaveOne apical crosssection modified convex triangular.

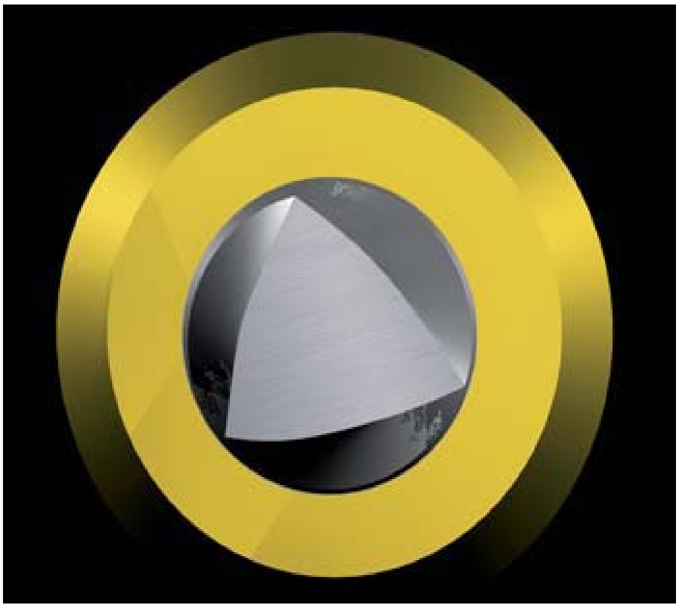


Fig (1-6) WaveOne convex triangular coronal crosssection.

The concept of single file usage:

The Wave-One technique is both a single-file and single-use concept. As stated, it is a single-file concept given that one single file is able to shape a secured canal to a well-shaped canal, in most instances.

The Wave-One concept must be considered a single-use concept due to the obvious stress and wear on the active portion of the file. This is in accordance with the growing concern in the dental community from cross-contamination between and among patients, regardless of the sterilization protocol utilized **(Letters et al., 2005).**

1.4.1.1 File selection:

Although there are 3 Wave-One files, the Primary 25/08 file is used first in any canal that has an open and smooth glide path equivalent to at least a loose 10 file. The primary 25/08 file can produce an optimal final shape in almost 90% of all canals, regardless of their length, diameter, and curvature **(Clifford, 2012).**

However, in longer, narrower, and more curved canals, even when the 10 file is loose at length, the Primary 25/08 Wave-One file will more predictably advance to the terminus of the canal when the glide path is expanded.

The Small 21/06 Wave-One file is used when the Primary 25/08 Wave-One file will not progress apically through a smooth reproducible glide path. The 21/06 is designed to work in smaller diameter, longer length, or more apically curved canals. In certain canals where it is thought that further preparation is needed the Small 21/06 is considered a "bridge file" because it acts as a transition to the 25/08 Wave-One file**(Clifford, 2012).**

The Large 40/08 Wave-One file is used to complete the shape in larger diameter canals that are typically straighter. Examples include certain maxillary incisors, single-canal bicuspids, and larger diameter canals within maxillary and mandibular molar teeth.

After carrying the Primary 25/08 file to the working length, gauging procedure is essential to confirm if the foramen is bigger than 0.25 mm. In this instance, it may be require that the 40/08 Wave-One file to fully shape and finish these larger canal systems. **(Clifford, 2012)**

1.4.1.2 Shaping Technique:

The specially designed NiTi files work in a similar but reverse "balanced force" action using a pre-programmed motor to move the files in a back and forth "reciprocal motion". The files are manufactured using M-Wire technology, improving strength and resistance to cyclic fatigue by up to nearly four times in comparison with other brands of rotary NiTi files.There are many dentists who, for whatever reason, are reluctant to use NiTi rotary instruments to prepare canals , despite the recognised advantages of flexibility,less debris extrusion and maintaining canal shape, amongst other advantages **(Julian et al.,2011)**.

The use of a single reciprocating file will be very attractive both in terms of time and cost saving.The WaveOne motor is rechargeable battery operated with a 6:1 reducing handpiece. The pre-programmed motor is set for the angles of reciprocation and speed for WaveOne instruments. The counterclockwise (CCW) movement is greater than the clockwise (CW) movement.CCW movement advances the instrument, engaging and cutting the dentine. CW movement disengages the instrument from the dentine before it can (taper) lock into the canal. Three reciprocating cycles complete one complete reverse rotation and the instrument gradually advances intothe canal with little apical pressure required**(Julian et al.,2011)**.

All brands of NiTi files can be used with theWaveOne motor, as it has additional functions for continuous rotation. However, as WaveOne files have their own unique reverse design, they can only be used with the WaveOne motor with its reverse reciprocating function**(Julian et al.,2011)**.

A brushing motion may be utilized to eliminate interferences, remove internal triangles of dentin, or to enhance shaping results in canals which exhibit an irregular cross-section. Removing canyons of restrictive dentin from the coronal two-thirds of a canal creates a more direct path to its apical one-third, improving accuracy when determining a precise working length **(Julian et al.,2011)**.

1.4.1.3 Reciprocation Movement:

The e3 motor (Dentsply Tulsa Dental Specialties) is specially engineered and programmed to drive the new WaveOne reciprocating files. This motor produces a feature-specific, unequal bidirectional file movement. Because of the reverse helix design, the CCW engaging angle is 5 times the CW disengaging angle. Additionally, it should be noted, this motor can drive any market version file system in full CW rotation at the desired speed and torque **(Julian et al.,2011)**.

There are 3 critical distinctions with this novel, unequal bidirectional movement.One, compared to continuous rotation, there is a significant improvement in safety, as the CCW engaging angle has been designed to be smaller than the elastic metallurgical limit of the file.

Two, opposed to all other reciprocating systems that utilize equal bidirectional angles, the WaveOne system utilizes an engaging angle that is 5 times the disengaging angle. After three engaging/disengaging cutting cycles, the WaveOne file will have rotated 360º, or turned one CCW circle. This unique reciprocating movement enables the file to more readily advance toward the desired working length.

Three, compared to an equal bidirectional movement,an unequal bidirectional movement strategically enhances auguring debris out of the canal. Auguring debris in a coronal direction promotes the biological objectives for preparing canals, 3D disinfection, and filling root canal systems **(Julian et al.,2011)**.

1.4.1.4 Studies related to Wave One :

Bürklein etal, in (2012) compared shaping ability and cleaning effectiveness of two reciprocating single-file systems with Mtwo and ProTaper rotary instruments during the preparation of curved root canals in extracted teeth. For debris removal, Mtwo and Reciproc instruments achieved significantly better results than the other instruments in the apical third of the canals. In the middle and coronal parts, no significant differences were obtained between Mtwo, Reciproc and WaveOne, while ProTaper showed significantly more residual debris. The results for remaining smear layer were similar and not significantly different for the different parts of the canals . They concluded that all instruments maintained the original canal curvature well and were safe to use. The use of Mtwo and Reciproc instruments resulted in better canal cleanliness in the apical part compared with ProTaper and WaveOne.

Mathieu Goldberg et al, in (2012) assessed the centering ability with a WaveOne 25.08 primary file with the effect of experience in simulated plastic canals. All three groups yielded satisfactory, reproducible shaping. They concluded that the WaveOne instrument had excellent centering ability with a low risk of fracture or blockage and a short shaping time, regardless of the operator's level of experience.

Kim et al, in (2013) studied by Micro-computed tomography and scanning electron microscopy comparisons of two nickel-titanium rotary root canal instruments used with reciprocating motion. This study was conducted to compare the shaping ability of single ProTaper F2 file and WaveOne Primary file when they were used in the curved root canal with reciprocation motion and to investigate the durability of the file after use with a scanning electron microscopy (SEM). Changes in structure model index (SMI), root canal volume, curvature, surface area, and degree of transportation were measured from the cross-sectional images of the prepared canals using the micro-CT system with an isotropic resolution of 16 μm. Results showed that there were no differences in the changes of root canal volume, surface area, and SMI between the two file groups after the preparation. The single-file technique using either WaveOne Primary or ProTaper F2 can be safely used under each reciprocating motion without creating an increased apical transportation in curved canals. However, the metallurgic property resists cyclic fatigue was more favorable with WaveOne under the scanning evaluation.

1.4.2 ProTaper Rotary System:

ProTaper (Progressively Tapered), nickel-titanium rotary files substantially simplify root canal preparation, particularly in curved and restricted canals. They consistently produce proper canal shaping that enables easy obturation by any vertical obturation method.

This instrument system, consisting of three “shaping” and three “finishing” files, was co-developed by Drs. Clifford Ruddle, John West, Pierre Machtou, and Ben Johnson and was designed by François Aeby and Gilbert Rota of Dentsply/Maillefer in Switzerland.

The distinguishing feature of the ProTaper System is the progressively variable tapers of each instrument that develop a “progressive preparation” in both vertical and horizontal directions.

When used, the file blades engage a smaller area of dentin, thus reducing torsional load that leads to instrument fatigue and file separation. During rotation, there is also an increased tactile sense when compared with traditionally shaped rotary instruments. “Taper lock” is reportedly reduced, therefore reducing the possibility of breakage **(Ingle, 2002).**

1.4.2.1 The shaping files

Shaping file # 1 and shaping File # 2, termed S1and S2, have purple and white identification rings on their handles, respectively. The S1 and S2 files have D0 diameters of 0.17 mm and 0.20 mm, respectively, and their D14 maximal flute diameters approach 1.20 mm **(Clifford,2001).**

The auxiliary shaping file, termed SX, has no identification ring on its gold-colored handle and, with a shorter overall length of 19 mm, provides an excellent access when space is restrictive. Because SX has a much quicker rate of taper between D1 and D9 as compared to the other ProTaper Shaping files, it is primarily used, after S1 and S2, to optimally shape canals in coronally broken down or anatomically shorter teeth. The SX file has a D0 diameter of 0.19 mm and a D14 diameter approaching 1.20 mm **(Clifford,2001).**

A unique feature of the ProTaper shaping files is each instrument has multiple “increasing” percentage tapers over the length of its cutting blades. This progressively tapered design serves to significantly improve flexibility, cutting efficiency, and safety. The progressively tapered design reduces the number of recapitulations needed to achieve length, especially in small diameter or more curved canals **(Clifford,2001).**

1.4.2.2 The finishing files

Three finishing files named F1, F2 and F3 have yellow, red and blue identification rings on their handles corresponding to D0 diameters of 0.20 mm, 0.25 mm, and 0.30 mm, respectively. Additionally, F1, F2, and F3 have fixed tapers between D1 and D3 of .07, .08, and .09, respectively . However, unlike the Shaping files, the Finishing files have “decreasing” tapers from D4-D14. This design feature serves to improve flexibility, reduce the potential for dangerous taper-lock, and prevent the needless over-enlargement of the coronal two-thirds of a root canal. Generally, only one instrument is needed to prepare the apical third to working length, and tip sizes (0.20, 0.25, 0.30) will be selected based on the canal’s curvature and cross-sectional diameter **(Clifford,2001).**

1.4.2.3 Protaper features and benefits

1. Multiple tapers

A unique feature of the Shaping files is their progressively tapered design which clinically serves to significantly improve flexibility, cutting efficiency and typically reduces the number of recapitulations needed to achieve length, especially in tighter more curved canals . As an example, the SX file exhibits nine (9) increasingly larger tapers ranging from 3.5%to 19% between D1 and D9, and a fixed 2% taper between D10 and D14. The S1 file exhibits twelve (12) increasingly larger tapers ranging from 2% to 11% between D1 and D14. The S2 file exhibits nine (9) increasingly larger tapers ranging from 4% to 11.5% between D1 and D14. This design feature allows each Shaping file to perform its own “crown down” work. One of the benefits of a progressively tapered Shaping file is that each instrument engages a smaller zone of dentin which reduces torsional loads, file fatigue and the potential for breakage **(Clifford,2001).**

2. Convex triangular cross-section

Another unique feature of the ProTaper instruments relates to their convex triangular cross-section . This feature reduces the contact area between the blade of the file and dentin, and serves to enhance the cutting action and improve safety by decreasing the torsional load. As is true with any instrument, increasing its D0 diameter and percentage taper correspondingly increases its stiffness. To improve flexibility, finisher No. 3 has a reduced core, as compared to the other instruments in the series **(Clifford,2001).**

3. Helical angle & pitch

ProTaper files have a continuously changing helical angle and pitch over their 14 mm of cutting blades . Balancing the pitch and helical angles of an instrument optimizes its cutting action, effectively allows its blades to engage debris out of the canal, and importantly prevents the instruments from inadvertently screwing into the canal **(Clifford,2001).**

4. Variable tip diameters

The three shaping files have variable D0 diameters to allow clinicians to safely and efficiently follow the canal while allowing each instruments' more coronal cutting blades to pre-enlarge specific zones of the canal. shaper No. 1 has a diameter of 0.17 mm at D0. shaper X has a diameter of 0.19 mm at D0 and shaper No. 2 has a D0 diameter of 0.20 mm.

The finishing files have variable D0 diameters of 0.20, 0.25 and 0.30 mm to address the obvious variations in cross-sectional diameters that canals exhibit in their apical one-thirds.Generally, only one finishing file is necessary to optimally finish the apical one-third of an anatomically difficult or significantly curved canal **(Clifford,2001).**

5. Modified guiding tip

Another specific feature of the ProTaper files is each instrument has a modified guiding tip. This design feature allows each instrument to better follow the canal and enhances its ability to find its way through soft tissue and loose debris without damaging the root canal walls **(Clifford,2001).**

6. <u>Short handles</u>

ProTaper files have short, 12.5 mm handles as compared to the more standard file handle length of 15 mm. This feature serves to improve access into the posterior regions of the mouth, especially when there is a narrow interocclusal space **(Clifford,2001).**

7. <u>Six instrument series</u>

The ProTaper system features just six NiTi files . In anatomically difficult or significantly curved canals, generally only three instruments are required to produce a fully tapered canal that exhibits uniform shape over length **(Clifford,2001).**

1.4.2.4 Studies related to protaper system :

Paqué et al, in (2005) compared various parameters of root canal preparation using RaCe (FKG Dentaire, Switzerland) and ProTaper (Dentsply Maillefer, Switzerland) nickel-titanium (Ni-Ti) instruments. Both Ni-Ti systems maintained curvature well. Following preparation with RaCe, 49% of the root canals had a round or oval diameter and 50% an irregular diameter, ProTaper preparations resulted in a round or oval diameter in 50% of the cases. For debris, RaCe and ProTaper achieved 47% and 49% scores of 1 and 2, respectively; there was no significant difference. For smear layer, RaCe and ProTaper achieved 51 and 33% scores 1 and 2, respectively; no statistically significant differences were apparent in the coronal and middle sections of the root canals, but RaCe performed significantly better in the apical region. They concluded that both systems respected original root canal curvature well and were safe to use. Cleanliness was not satisfactory for both systems.

Brkanić etal., in (2010) investigated the influence of different NiTi files including rotary ProTaper, GT, ProFile, K-3, FlexMaster, Hand ProTaper and hand GT on the canal wall cleaning quality, residual dentine debris and smear layer. The least amount of debris and smear layer had been found in canals shaped with ProFile instruments, and the largest amount in canals shaped with FlexMaster instruments. Canal cleaning efficacy of hand GT and ProTaper files was similar to cleaning efficacy of rotary NiTi files. Statistic analysis showed a significant difference in amount of dentine debris and smear layer on the canal walls between sample groups shaped with different instruments. They concluded that completely clean canals have not been found in any tested group of instruments. The largest amount of debris and smear layer was found in the apical third of all canals. The design and the type of endodontic instruments influence the efficacy of the canal cleaning.

Caron et al., in 2010 compared the effect of different final irrigation regimens and methods of activation on smear layer removal in curved canals after root canal instrumentation.Mesial root canals of 50 extracted mandibular molars were prepared using ProTaper rotary files and 3% NaOCl. Teeth were then allocated to two control groups and four experimental groups (n = 10) for final irrigation as follows: no-activation group (final rinse with a 27-gauge needle and 17% EDTA/3% NaOCl), manual-dynamic activation group (final rinse 17% EDTA/3% NaOCl + gutta-percha agitation), automated-dynamic activation group (final rinse 17% EDTA/3% NaOCl + RinsEndo and sonic-activation group (final rinse 17% EDTA/3% NaOCl + Endoactivator. The samples were prepared for scanning electron microscopic observation to assess the smear layer removal. They concluded that root canal cleanliness benefits from solutions activation (especially sonic activation and manual-dynamic activation) in comparison with no activation during the final irrigation regimen.

Brkanić etal., in (2012) did measurement of maximal and minimal residual dentine thickness (RDT) and canal diameter after the canal preparation with different NiTi rotary files including rotary ProTaper, GT, ProFile, K-3, FlexMaster, hand ProTaper, and hand GT. The maximal residual dentine thickness at distance 1 mm from apex, ranged from 1.16 to 1.45 mm, and at distance 3 mm from apex, from 1.44 to 1.84 mm. The minimal dentine thickness at distance 1 mm from apex ranged from 0.52 to 0.73 mm, and at distance 3 mm from apex, from 0.66 to 0.83 mm. The canal diameters after preparation at distance 1 mm from apex ranged from 0.42 to 0.49 mm, and at distance 3 mm from apex, from 0.53 to 0.63 mm. They conclude that there was no significant difference neither in maximal and minimal RDT, nor in canal diameters shaped with different NiTi instruments tested. All tested NiTi files have accomplished good quality preparation of apical root canal parts.

1.4.3 Step-back technique :

The concept of the step-back (also known as flaring or serial preparation) technique was first described by Clem" in **(1969)** and became popular when a series of research report indicated its superiority over the standardized preparation techniques. In addition, the step-back technique creates a smoother flow and a more tapered preparation from apical to coronal direction. The step-back technique with stainless steel instruments is the most widely taught and used technique in that time **(clem ,1969).**

A step-back technique is the sequential use of instruments, starting with the smaller sizes and progressing toward the larger sizes, regardless of the type of instrument series used **(Coffae and Bnilliant ,1975).**

1.4.3.1 Objective

The objective is to keep the apical preparation as small as practical (but well debrided) with an increasing taper throughout the canal. The final apical preparation should be at or close to the original canal position. It is desirable to remove a layer of dentin from all canal walls from apical to coronal. Such removal has been shown to be difficult but is more achievable with the flaring techniques **(Richard and Mahmoud,2002).**

1.4.3.2 Method

The basic method of canal preparation for any flaring technique is as follows:

1. Negotiate the canal space with small files to length.
2. Remove coronal dentin (enlarge the coronal canal) to facilitate placement of larger files in the middle and apical regions. This is performed with Gates-Glidden burs, orifice openers, or hand files.
3. Determine the size of the file that corresponds with the size of the most apical canal space. This is the "master apical file."
4. Enlarge the apical and middle canal spaces with a flaring preparation (step-back or crown-down) to clean and shape **(Richard and Mahmoud,2002).**

1.4.3.3 Apical Preparation:

This is the next step after straight-line access is made and the MAF size is determined. To keep the canal small but debrided, the apical 1 to 2 mm of the canal is enlarged by reaming, generally to only one or two sizes larger than the MAF Care is required to not overprepare the apical region, particularly in the curved canal **(Richard and Mahmoud,2002).**

As the curvature becomes greater, a smaller apical preparation is needed. If the canal is small and the curvature is more than slight, the MAF is usually no larger than a No. 20 file. If the apical portion of the curved canal is anatomically larger than a No. 25 file, to minimize transportation, no attempt should be made to enlarge this region further than the size of the file that shows slight binding. when instrument binds slightly at length is used; this will be the MAF. Step-back is begun from this point **(Richard and Mahmoud,2002).**

Taper: After apical preparation, tapering of the remaining canal is created by shortening the working length of each successively larger instrument by 0.5 mm and by performing peripheral filing. This creates the step-back.

Recapitulation: After each step-back file is used, recapitulation is performed by returning to length with the MAF (or smaller file). The instrument is rotated carefully to loosen debris but not enlarge the apical canal.

Irrigation: At least 2 ml of irrigant is used between each file size after recapitulation **(Richard and Mahmoud,2002).**

Size of Preparation: Step-back instrumentation up to at least a size 70 file is usually necessary. This should give adequate debridement of most of the canals as well as sufficient taper to permit deep spreader (or plugger) penetration. A larger stepback is indicated in larger canals.

Final Apical Enlargement: This will improve debridement of the apical portion of the canal **(Richard and Mahmoud,2002).**

1.4.3.4 Step-Back Preparation and Curved Canals:

This method of preparation has been well described by Mullaney in 1979. His approach has been modified, however, to deliver a continuing tapered preparation. Mullaney divided the step-back preparation into two phases:

Phase I is the apical preparation starting at the apical constriction.

Phase II is the preparation of the remainder of the canal, gradually stepping back while increasing in size. The completion of the preparation is the Refining Phase IIA and IIB to produce the continuing taper from apex to cervical **(Mullaney, 1979)**.

Although the step-back technique was designed to avoid zipping the apical area in curved canals, it applies as well to straight canal preparation. All root canals have some curvature. Even apparently straight canals are usually curved to some degree. Canals that appear to curve in one direction often curve in other directions as well **(Buchanan, 1991).**

1.4.3.5 Studies related to step-back technique :

Singla etal, in (2010) evaluated the effect rotary ProTaper, Profile, and conventional stepback technique on reduction in Enterococcus faecalis colony-forming units and vertical root fracture resistance of root canals. Root canals instrumented with ProTaper and 6% Profile instruments showed maximum reduction in CFUs, with statistically insignificant difference between them.

Siqueira etal., in 1997 did histological evaluation of the effectiveness of five instrumentation techniques for cleaning the apical third of root canals.The efficacy of five instrumentation techniques for cleaning the apical third of curved root canals was assessed by histological examination. Mesial root canals of freshly extracted human mandibular molars were prepared by the following instrumentation methods: step-back technique using stainless steel files; step-back technique using nickel-titanium files; ultrasonic technique; balanced force technique; and Canal Master U technique and instruments. The apical portion of the root was histologically processed, and cross-sections were examined for remaining soft tissue, predentin, and debris. The results showed no significant differences among the techniques. Although the five instrumentation methods were effective in removal of major amounts of tissue from the canals, none totally debrided the entire root canal system, especially when variations in the internal anatomy were present.

Richard Archer et al., in (1992) histologically compared the in vivo debridement efficacy of the step-back preparation versus a step-back/ultrasound preparation in the mesial root canals of vital mandibular molars. The canal and isthmus cleanliness values were significantly higher, at all 11 apical levels, with the ultrasonic technique. Sample values at the 1-, 2-, and 3-mm levels for the step-back and step-back/ultrasonic techniques, respectively, were: canal, 64%

versus 92%, 81% versus 97%, and 90% versus 99.9%; isthmus, 2% versus 46%, 15% versus 60%, and 16% versus 83%.

John Haidet et al., in (1989) compared the debridement efficacy of the step-back preparation versus a step-back/ultrasound preparation in the mesial root canals of vital human mandibular molars. Following extraction and histological preparation, the 1- and 3-mm levels of the canal and isthmus were evaluated for percentage of tissue removal using a compensating polar planimeter. At the 3-mm level, there were no statistical differences in canal or isthmus cleanliness between the step-back group and the step-back/ultrasound group. At the 1-mm apical level, statistical analysis indicated that the step-back/ultrasonic technique was superior to the step-back technique in canal (99.6% versus 88%) and isthmus (86% versus 10%) cleanliness.

1.5 EndoActivator system

The EndoActivator System is comprised of a hand piece and variously sized polymer tips. This sonically driven system is designed to activate various intracanal reagents and vigorously produce the hydrodynamic phenomenon. Sonic activation has been shown to be an effective method to improve disinfection **(Pitt ,2005).**

Research has shown that the EndoActivator System is able to debride into the deep lateral anatomy, remove the smear layer, and dislodge simulated biofilm clumps within the curved canals of molar teeth **(Caron ,2007).**

During use, the action of the EndoActivator tip frequently produces a cloud of debris that can be observed within a fluid-filled pulp chamber. The primary function of the EndoActivator is to produce vigorous intracanal fluid agitation through acoustic streaming and cavitation. This hydrodynamic activation serves to improve the penetration, circulation, and flow of irrigant into the more inaccessible regions of the root canal system. Cleaning root canal systems provide an opening for three-dimensional obturation and long-term success **(Guerisoli et al, 2002).**

1.5.1 Sonic handpiece

The sonic handpiece is cordless, contra-angled, and ergonomic, and is used to drive the EndoActivator tips. The handpiece is operated by depressing the light-touch ON/OFF switch that activates the strong and flexible polymer tips. The 3-speed sonic motor switch provides options of 10,000, 6,000 and 2,000 cycles per minute (cpm). When the handpiece is activated, the power defaults to 10,000 cpm, which research has shown to be the recommended speed to maximize debridement and disruption of the smear layer and biofilm **(Caron ,2007).**

The other lower speeds are selected based on different clinical applications and the power needed to effectively accomplish those tasks. The sonic motor is energized by, preferably, a single lithium battery. For infection control, custom protective barrier sleeves have been designed to easily slide over the entire handpiece **(Clifford ,2008).**

1.5.2 EndoActivator tips

The EndoActivator tips have an easy snap-on/snap-off design and are color-coded yellow, red, and blue, corresponding to small, medium and large sizes, respectively . The yellow, red, and blue color-coded activator tips closely correspond to file nomenclature sizes 20/02, 25/04, and 30/06, respectively. The tips are made from a medical-grade polymer, are strong and flexible, and are 22 mm long . The polymer tips will not cut dentin, therefore will not ledge, apically transport, or perforate a canal .The EndoActivator tips are disposable. The EndoActivator tip selected is placed over the barrier-protected driver and is simply snapped on to secure its connection to the handpiece **(Clifford ,2008).**

1.5.3 Tip Selection

An underprepared canal or selecting a tip that is too large will serve to dampen or restrict tip movement, which in turn will limit its ability to agitate a solution. Research has shown that just moving a tapered gutta percha cone or polymer tip up and down in short 2-3 mm vertical strokes in a tapered preparation produces a surprising hydrodynamic effect **(Caron ,2007).**

When the selected tip moves toward the full working length, then its shape more closely approximates the shape of the prepared canal. This, in turn, serves to displace any given reagent laterally while allowing safe reflux coronally. Vibrating the tip, in combination with moving the tip up and down in short vertical strokes, synergistically produces a powerful hydrodynamic phenomenon . In general, 10,000 cpm has been shown to optimize debridement and promote the disruption of the smear layer and biofilm. When the clinical procedure has been completed the activator tip and barrier sleeve should be discarded **(Caron ,2007).**

1.5.4. Studies related to EndoActivator:

Desai and Himel in 2009 Compared the safety of various intracanal irrigation systems by measuring the apical extrusion of irrigant. This study showed that the EndoVac did not extrude irrigant after deep intracanal delivery and suctioning the irrigant from the chamber to full working length. EndoActivator had a minimal, amount of irrigant extruded out of the apex when delivering irrigant into the pulp chamber and placing the tip into the canal and initiating the sonic energy of the EndoActivator. Manual, Ultrasonic, and Rinsendo groups had significantly greater amount of extrusion compared with EndoVac and EndoActivator.

Townsend and Mak in 2009 compared a new irrigation and agitation techniques to ultrasonic agitation in removing bacteria from a simulated root canal .This in vitro study compared 3 agitation and 2 irrigation devices to ultrasonic agitation at mechanically removing bacteria from a plastic simulated canal, instrumented to 35/.06. They concluded that In a plastic simulated canal, ultrasonic agitation was significantly more effective than needle irrigation and EndoVac irrigation at removing intracanal bacteria. Ultrasonic, EndoActivator, F-File, and sonic agitation are similar in their ability to remove bacteria in a plastic simulated canal.

Rödig et al, in 2010 evaluated the effectiveness of different irrigant agitation techniques (ultrasonic, EndoActivator, and CanalBrush) on debris and smear layer removal in curved root canals: a scanning electron microscopy study. Concerning debris removal, no significant differences among groups were detected. In the coronal region, agitation of the irrigants resulted in significantly more smear layer removal than the control. EndoActivator was significantly more effective than ultrasonic agitation and CanalBrush.In curved root canals, activation of NaOCl and ethylenediaminetetraacetic acid did not enhance debris removal but resulted in significantly more effective smear layer removal at coronal levels.

Paragliola etal., in 2010 examined the effect of different root canal irrigant agitation protocols in the penetration of an endodontic irrigant into dentinal tubules .The results supported the use of an ultrasonic agitation to increase the effectiveness of the final rinse procedure in the apical third of the canal walls.

1.6 Histopathology:

The tissue undergoes a series of steps before it reaches the examiners desk to be thoroughly examined microscopically to arrive at a particular diagnosis.To achieve this it is important that the tissue must be prepared in such a manner that it is of sufficient thick or thin to be examined microscopically and all the structures in a tissue may be differentiated**(Lillie,1965;Bancroft et al,1990).**

1.6.1 Types of Histological preparation

The histological specimen can be prepared as:

1. Whole mount.
2. Sections.
3. Smears.

This study is on the section type of histological preparation. The tissue is cut in about 3-5 mm thick pieces processed and 5 microns thick sections are cut with a microtome. These are then stained and permanently mounted.

Microtomes are special instruments which have automatic mechanism for cutting very thin sections. To cut the sections on the microtome;the tissue must be made hard enough to not get crushed. There are 2 methods of hardening the tissues. One is by freezing them and the other is by embedding them in a hard material such at paraffin wax or gelatin**(Lillie,1965;Bancroft et al,1990).**

1.6.2.Fixation

It is a complex series of chemical events which brings about changes in the various chemical constituents of cell like hardening, however the cell morphology and structural detail is preserved.

Unless a tissue is fixed soon after the removal from the body it will undergo degenerative changes due to autolysis and putrefaction so that the morphology of the individual cell will be lost**(Lillie,1965;Bancroft et al,1990).**

1.6.3 Principle of fixation:

The fixative brings about crosslinking of proteins which produces denaturation or coagulation of proteins so that the semifluid state is converted into semisolid state; so that it maintains everything in vivo in relation to each other. Thus semisolid state facilitate easy manipulation of tissue. **(Lillie,1965;Bancroft et al,1990).**

1.6.4 Amount of fixative

The fixative should be atleast 15-20 times the bulk of tissue. Formalin is one of the commonly used fixative in all laboratories since it is cheap penetrates rapidly and does not over harden the tissues. Pure formalin is not a satisfactory fixative as it overhardens the tissue. A 10% dilution in water (tap or distilled) is satisfactory**(Lillie,1965;Bancroft et al,1990).**

1.6.5 Decalcification:

It is a process of complete removal of calcium salt from the tissues like bone and teeth and other calcified tissues following fixation.

Decalcification is done to assure that the specimen is soft enough to allow cutting with the microtome knife. Unless the tissues in completely decalcified in the sections will be torn and ragged and may damage the cutting edge of microtome knife. Nitric acid- 5-10% aqueous solution used. **(Lillie,1965;Bancroft et al,1990).**

1.6.6 Tissue processing

It is refers to treatment of the tissue necessary to impregnate it into a solid medium so that the tissue is rendered sufficiently firm yet elastic for the tissue sections of desirable thickness to be cut on microtome.

The embedding medium has to thoroughly permeate the tissue in fluid form so that it solidifies without any damage to the tissue. The most satisfactory embedding medium used in routine histology is paraffin wax**(Lillie,1965;Bancroft et al,1990).**

1.6.7 Properties of paraffin wax

1. Easy to prepare large number of tissue blocks in comparatively short time.
2. Minimum supervision is required
3. It is cheaper than other impregnating media
4. During staining there is very little difficulty than other media.

Leuckhart's L pieces :These are two 'L' which are resting metal usually brass, which are resting on a flat metal or glass plate**(Lillie,1965;Bancroft et al,1990).**

1.6.8 Microtomes

These are mechanical devices for cutting uniform sections of tissue of appropriate thickness. All microtomes other than those used for producing ultra thin sections for election microscopy depend upon the motion of a screw thread in order to advance the tissue block on knife at a regulated number of microns.

The sections, as they are prepared, are colourless and different components cannot be appreciated. Staining them by different coloured dyes, having affinities of specific components of tissues, makes identification and study of their morphology possible.The most common stain applied for histological study is Haemotoxylin and Eosin**(Lillie,1965;Bancroft et al.,1990).**

Azorit et al, in2002 obtained thin histological sections (4–5 μm thick) from teeth, using a conventional microtome, is described for incisors, molars and canines from Spanish red deer *(*Cervus elaphus hispanicus*)*. Decalcifying solutions of formic acid and nitric acid at different concentrations were ineffective. However, the time needed to complete decalcification was longer than the time estimated by other authors. Incisors required between 4 and 6 days, molars between 7 and 15 days, and canines between 8 and 12 days . This technique is inexpensive enough to be implemented in any histological laboratory. The preparations obtained are suitable for growth mark observation in dentine and in cementum for dating studies. Nevertheless, they are not suitable for enamel change studies, because the enamel is completely destroyed during the decalcifying process.

Karpagaselvi et al,in 2012 evaluated the rate of decalcification of six different decalcifying agents and also their effect on staining characteristics on dental hard tissues. Neutral EDTA was the most considerate to the soft and hard tissues and 5% nitric acid was the least considerate to the tooth structure. He concluded that Neutral EDTA, though being the slowest decalcifying agent among the six agents used in the study, gave excellent results for soft-tissue integrity, and best quality of both soft-tissue and hard-tissue stainings.

Materials and Methods

2.1.Materials and equipments :

1. Alcohol .(China)
2. DCM 35 microscope camera (Zhejiang Hangzhou , China).
3. Digital camera 400X . (China)
4. Disposable syringe (5ml\gauge 23) for irrigation (medico inject, UAE, Exp.Date 2014-10)
5. Endoactivator Handpiece . (Dentsply Maillefer ,Switzerland) .
6. Endoactivator tips small #15/.02 (Dentsply Maillefer ,Switzerland) .
7. Endodontic ruler Mini-Endobloc (Dentsply Maillefer ,Switzerland) .
8. Formalin (10%) .(Maharashtra, India Exp.Date 2014-7).
9. H & E stain . (China)
10. K – type files size 10 - 90 (Dentsply Maillefer,Switzerland) .
11. Latex gloves (TG Medical, Malaysia.Exp.Date:08/2016).
12. Leuckhart 's L shape .(China)
13. Light microscope (Leitz Wetzlar, germany) .
14. Microtome (U-Therm International (H.K.) Limited ,China)
15. Microtome knife .(China)
16. Nitric acid (5%) (Maharashtra, India Exp.Date 2015-1).
17. Normal saline (Al-Mottahedoon , pharma ,Egypt ,Exp.Date 2014-11).
18. Paraffin wax (sarawak , Malaysia) .
19. Prosthetic engine with straight hand piece (W&H ,Austria)
20. Protaper files Sx ,S1,S2 ,F1, F2 (Dentsply Maillefer ,Switzerland) .
21. Rubber stoppers (Dentsply Maillefer,Switzerland) .
22. Slide cover .(China)
23. Slides .(China)
24. Thin diamond cutting disc (Topdent , Switzerland) .
25. Thirty extracted human mandibular first molars.

26. Wave one files small, primary files (Dentsply Maillefer,Switzerland) .
27. Wave One™ motor . (Dentsply Maillefer ,Switzerland) .
28. Xylol (Maharashtra, India Exp.Date 2014-9) .

2.2. Methods

2.2.1.Sampling:

Seventy nine human mandibular first molars were collected and only thirty teeth were selected depending on the inclusion criteria .

The inclusion criteria of the mesial roots that were involved in this study are:

1. The length between the orifice and the apex was 12 mm.
2. Presence of the isthmus between the root canals.
3. No crack presented in the root.
4. The apical part of the root presented not fractured.
5. The root apex is closed not open apex.

The crown and distal root were sectioned using prosthetic engine with straight hand piece (W&H ,Austria) by thin diamond disk and removed figure(2-1).

Fig (2-1) Decoronation**.**

2.2.2 Grouping :

2.2.2.1.Group one

Ten teeth (20 root canals) were prepared by rotary Protaper universal system (Figure 2-2). This was accomplished by establishing a smooth glide path with ISO No. 10 stainless steel hand files . Preparation of the root canal started by:

-SX and then S1 instruments, preparing the coronal third of root canal .

-S2 instrument was used to prepare the middle third of root canal 1.0 Ncm .

- F1 instrument and finally F2 instrument were used to prepare the apical third of root canal **(Young and Yong.,2012)**.

Figure (2-2) Rotary Protaper files.

2.2.2.2.Group two:

Ten teeth were prepared by Wave One system figure(2-3); reproducible glide path equivalent to a loose 10 file, then started by the Small (21/06) file, irrigated, recapitulated with a 10 file, then re-irrigated. Then Primary (25/08) file was used for a full working length of 1 mm shorter than the apex **(Goldberg et al 2012)**, irrigated, recapitulated with a 10 file, then re-irrigated.

Figure (2-3) Wave One™ motor.

2.2.2.3.Group three :

Ten teeth were prepared by step-back technique; started by figure (2-4):

1. Used of size 10 file to full working length which was 11mm.
2. Used of size 15 file to full working length which was 11mm.
3. Used of size 20 file to full working length which was 11mm.
4. Used of size 25 file to full working length (regarded as a master apical file).
5. Used of size 30 file 10 mm which is1mm shorter than the working length, irrigated, recapitulated and reirrigated .
6. Used of size 35 file at 2 mm shorter than the working length, irrigated, recapitulated and reirrigated .
7. Used of size 40 file at 3 mm shorter than the working length, irrigated, recapitulated and reirrigated .
8. Used of size 45 file at 4 mm shorter than the working length,irrigated, recapitulated and reirrigated .
9. Used of size 50 file 5 mm shorter than the working length,irrigated, recapitulated and reirrigated .
10. Used of size 55 file at 6 mm shorter than the working length, irrigated, recapitulated and reirrigated .
11. Used of size 60 at 7 mm shorter than the working length, irrigated, recapitulated and reirrigated .

12. Used of size 70 file at 8 mm shorter than the working length, irrigated, recapitulated and reirrigated .

13. Used of size 80 at 9 mm shorter than the working length, irrigated, recapitulated and reirrigated .

14. Used of size 90 file at 10 mm shorter than the working length. irrigated, recapitulated and reirrigated **(Lumley ,2000).**

Figure (2-4) k-files used in step back technique.

Each group was subdivided into two subgroups each contained 5 roots (10 root canals); subgroup A was irrigated by normal saline and hypodermic syringe, subgroup B was irrigated by normal saline and endoactivator system (figure 2-5) by insertion of the tip size 20 for 30 seconds for each root canal.

Figure(2-5) Endoactivator hand piece and tips.

The canals were irrigated between each instrument with 10 ml. normal saline divided according to the number of instrument used in each group, recapitulated with ISO no.10 file to maintain patency to full working length and then reirrigated with normal saline .

2.2.3. Histological procedure :

After preparation:

For each subgroup, the roots were placed in a container and written the name of subgroup on it. The roots of all groups were placed in a formalin solution (10 %) for 3 days for fixation.

-Then the roots were placed in nitric acid solution (5 %) also for 3 days for decalcification for complete removal of calcium ions from the teeth following fixation **(Bancroft and Stevens ,1990)** .

Decalcification was done to ensure that the specimen is soft enough to allow cutting with the microtome knife. Unless the tissue is completely decalcified the sections will be torn and be ragged and may damage the cutting edge of microtome knife.

After that, the roots were sectioned at 2mm, 6mm, and 12mm from the apex respectively. Then the sections were placed in alcohol with a concentration of 70% over a night, then placed in a concentration of 90% for one hour then 100% for one hour, after that the sections placed in a xylol for 20 minutes. **(Bancroft and Stevens ,1990)**

The sections were placed in paraffin wax and placed in oven at a temperature between 60 – 80 c˚ for 2 hours. Two Leuckhart's L- shape metal (Figure 2-6) were met to make a box which contained the root section which filled by melted paraffin wax then left to be hard at room temperature after that placed in refrigerator for 15 minutes **(Bancroft and Stevens ,1990)**.

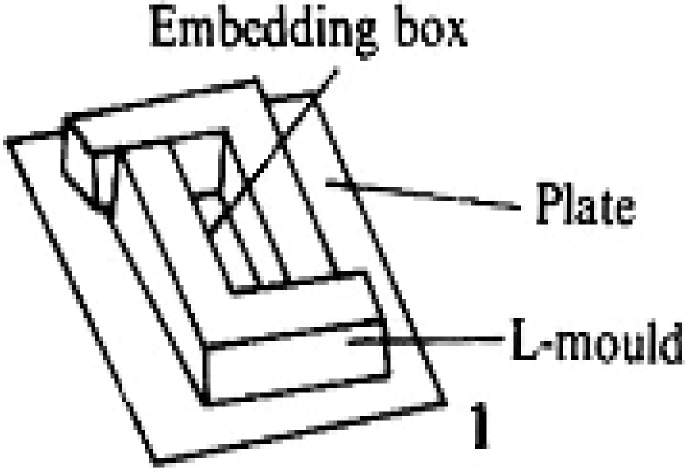


Figure (2-6) Two Leuckhart's L- shape metal.

The block of each root sections was embedded in a solid medium which helps in removing the tissue water which is then replaced by any solid medium such as paraffin wax so that the tissue is rendered firm enough to enable thin sections to be cut, at the same time, the tissue is soft to enable microtome knife to cut the sections. The block of each root and paraffin wax was cut by using microtoms (Figure 2-7) to 4 micron thickness section **(Bancroft and Stevens ,1990)**.

Figure (2-7) Microtome.

- Then the sections were fixed on a slide by using adhesive which is a substance can be smeared on to the slides so that the sections stick well to the slides. Then dewaxing was done by placing the slide in the oven for 20 minutes, after that the slides were placed in 3 jars of xylol each for 10 minutes inside the oven.

6. Then the slides were placed in alcohol solution 80 %, 90 %, and 100 % respectivelywhich is dehydration agent to remove tissue fluid which was replaced by paraffin wax .
7. The slides were washed by tap water.
8. After washing the slides were stained with hemotoxyline stain for 3 minutes then washed by tap water then eosin stain for 1 minute then washed, after that , they were placed in 3 jars of alcohol with a concentration of 100 % then 90 % then 80 % respectively (dipping only).
9. Mounting the cover slide or cover slip on the slide by using Canada balsam or dpx. Finally the slide was ready for microscopic evaluation.

2.2.4. Microscopic evaluation:

The slides were read by light microscope at 40X magnification power, then a high resolution picture was taken to each section on the slide by DCM 35 digital eye piece camera (Figure 2-8) which is a digital camera especially designed for microscope inserted directly into the ocular-tube or the photo-tube. It works perfectly with biological microscope and stereo microscope with one side connected to microscope and the other side connected by USB wire to computer.

Figure (2-8) DCM 35 digital camera**.**

1-Study one: evaluated the unclean to clean root canal wall percentage. The sections were stained by H&E stain to verify the organic debris at the inner wall of the root canal. This was drawn by the use of AutoCad system to measure the surface of the root canal cross section at different sections that was cleaned (without any debris which will be stained) to unclean surface (devoid of any debris).Each canal was divided to four part to be seen the whole canal outline under magnification power 40X.

The reading was presented as percentage of uncleaned wall surface . Then a microscopic picture of canals (Figure 2-9) was drawn by soft ware AutoCade 2004 system for sections at 12 mm from the apex (at root canal orifice), 6 mm from the apex, 2 mm from the apex for each sub group to show the unclean to clean surface area as percentage by draw first the canal to represent the whole area tracing the outline of the root canal by using poly line by soft ware AutoCade 2004 .

Then draw the unclean part and measured the unclean part and subtracted the uncleaned part to cleaned part as percentage to all canal area.

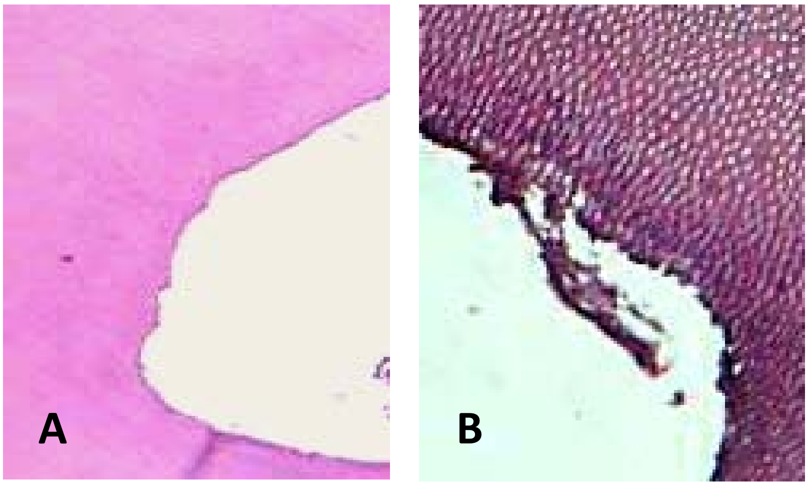


Figure (2-9) A- clean canal wall. B- un clean canal wall.

2-Study two : evaluated the unclean to clean surface percentage in the isthmus. This procedure was done in the same way as the previous study, but the isthmus was included in this study.

The isthmus was calculated from the imaginary continuous line of the circle of the root canal (Figure 2-10).

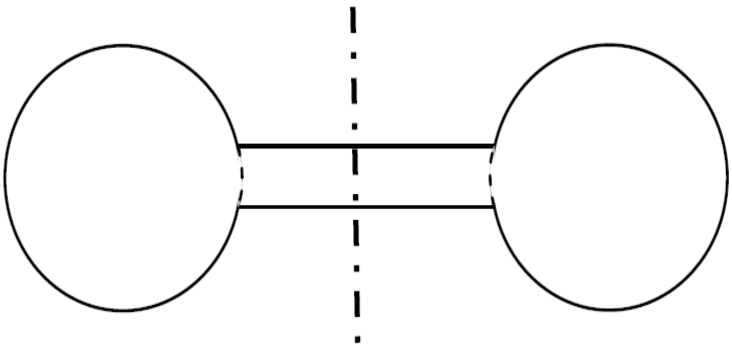


Figure (2-10) Diagram represent isthmus as imaginary continuous line of the circle of the root canal .

The isthmus was divided into two parts and a microscopic picture was taken under magnification power 40X (Figure 2-11) , then isthmus was drawn by soft ware AutoCade 2004 system for sections at 12 mm from the apex (root canal orifice), 6 mm from the apex, 2 mm from the apex for each sub group to show the unclean to clean surface area as a percentage by draw first the isthmus of each canal to represent the whole area by tracing the border of the isthmus then draw the unclean part and subtracted the uncleaned part to cleaned part as percentage to all canal area.

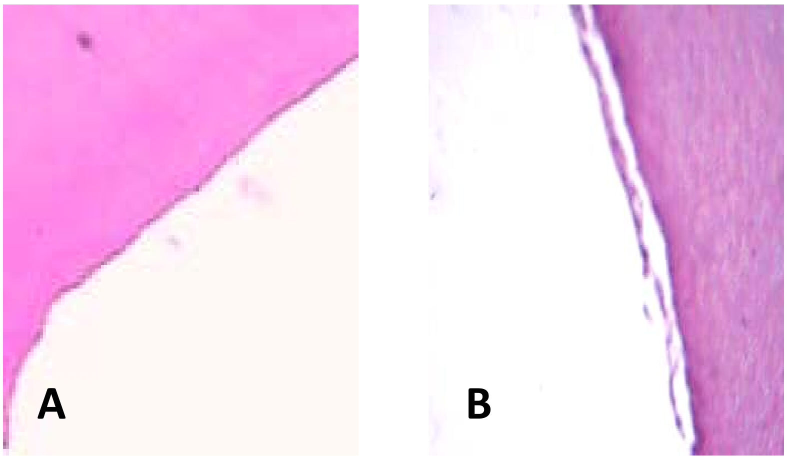


Figure (2-11) A- clean isthmus wall. B- un clean isthmus wall.

3-Study three : which measured :

A- The percentage of increase in canal diameter by using different rotary systems at root canal orifice.

B -The percentage of decrease of isthmus size at the orifice region.

High resolution picture was taken by digital camera (Figure 2-12) for each root before and after preparation at level of root canal orifice and the magnification used was 100X. The root was placed in aplastic mold which made from slicon and it diamension was 2 cm length ,3 cm width and 2 cm elevation as a holder to maintain the same position of the root before and after preparation.

The ruler was placed beside the mold to obtain the correct dimension measurement. The camera was placed at fixed position on the table and at the same distance from each root which was 20 cm during picture capturing, to prevent any variation in dimension between roots during measurement and comparison between dimensions.

Figure (2-12) Digital camera.

Then AutoCad 2004 soft ware system was used to draw each canal and isthmus by using poly line to draw the outline of canals and isthmus before and after instrumentation to measure the difference in canal diameter before and after instrumentation ,and the length of isthmus before and after instrumentation for each group.

Then a formula was used to show the percentage of increasing in canal diameter which was (canal diameter after instrumentation-canal diameter before instrumentation)*100/canal diameter before instrumentation.The percentage of decreasing in isthmus size after instrumentation was measured by formula which was (isthmus size after instrumentation- isthmus size before instrumentation) *100/ isthmus size before instrumentation .

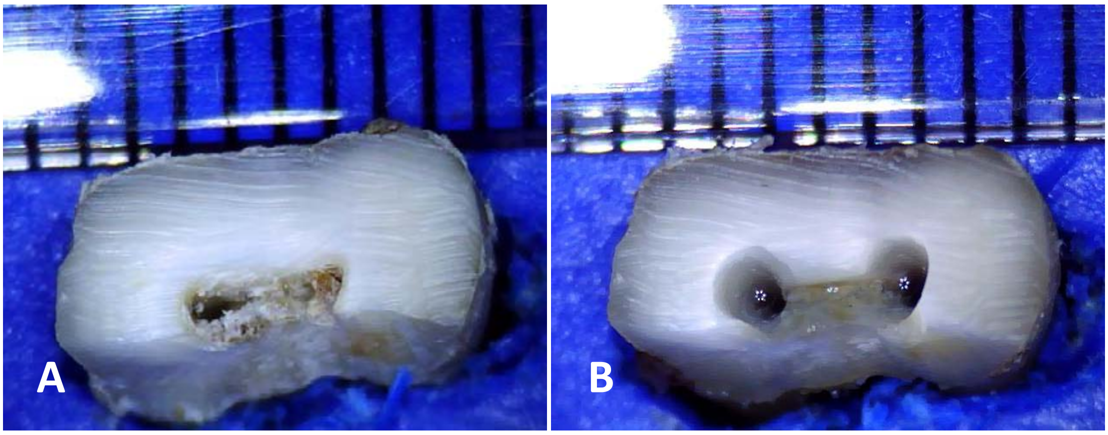


Figure (2-13) A-Mesial root before instrumentation **B-**After instrumentation by Protaper files.

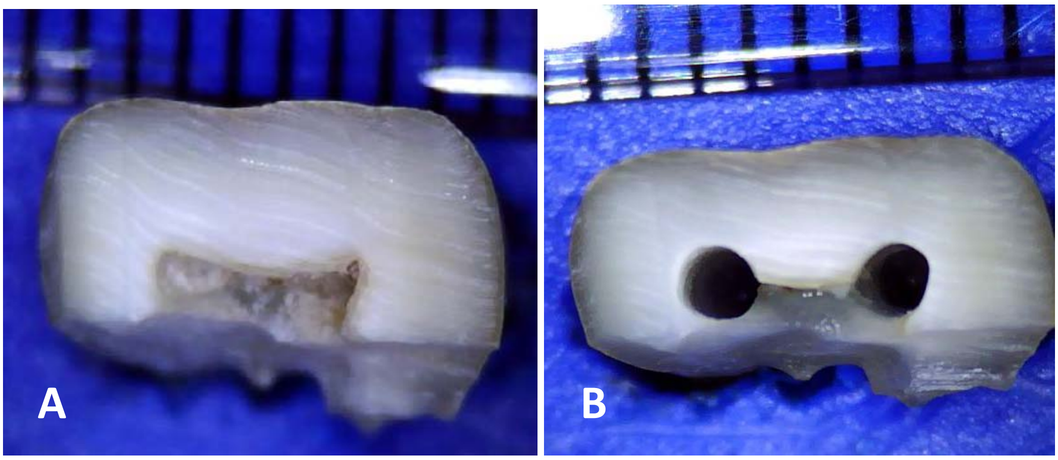


Figure (2-14) A- Mesial root before instrumentation **B-** After instrumentation by Wave One files.

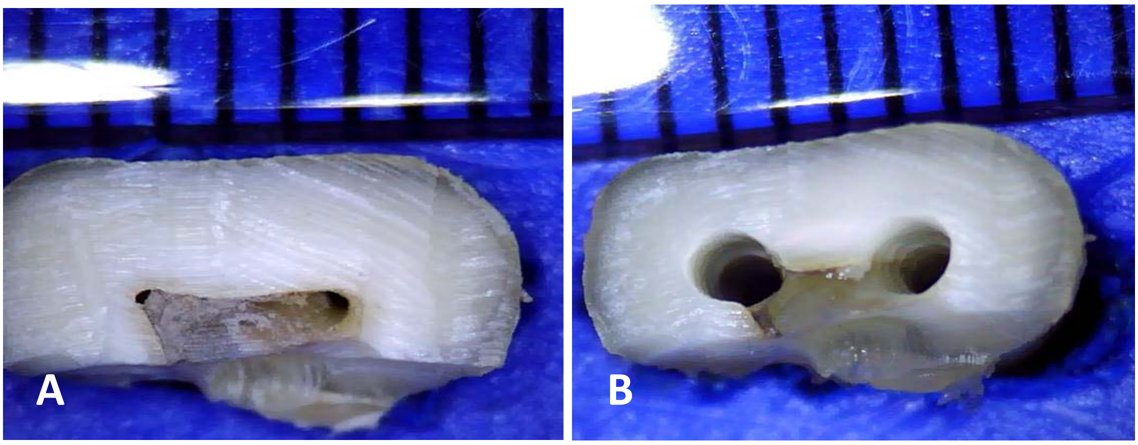


Figure (2-15) A- Mesial root before instrumentation **B-** After instrumentation by step back technique.

Results

The data collected represented three separated studies which were:

1- The percentage of unclean root canals surface area after instrumentation by different rotary instrument with different irrigation system at three sections (12 mm from apex, 6 mm from apex and 2 mm from apex).

2- The percentage of unclean isthmus surface area after instrumentation by different rotary instruments with different irrigation systems at three sections (12 mm from apex, 6 mm from apex and 2 mm from apex).

3- The third study included:

A- The percentage of increase in canal diameter by using different rotary systems at root canal orifice.

B -The percentage of decrease of isthmus size at the orifice region.

3.1. The comparison among the six groups in the percentage of unclean root canals surface area after instrumentation.

Data in the first study represent the percentage of unclean root canals surface area after instrumentation by different rotary instruments with different irrigation systems at three sections (12 mm from apex, 6 mm from apex and 2 mm from apex).

The comparison among groups in the least uncleaned surface at each section was the mean of each group the lowest mean the least uncleaned root canals surface area is shown in table (3-1).

The least uncleaned root canal surface area according to preparation techniques was protaper system,and according to the irrigation systems was EndoActivator system.

Table (3-1) The means of percentage of unclean root canals surface area at 12mm,6mm,2mm from the apex .

Sections	Group 1 A	Group 1B	Group 2A	Group4 2B	Group 3A	Group 3B
canal orifice (12mm from apex)	15.85	12.21	22.13	15.05	38.06	35.94
6 mm from apex	14.77	9.14	17.17	13.7	28.04	25.19
3 mm from apex	22.02	18.55	24.22	19.05	23.4	20.51

The least uncleaned root canal surface area at 12 mm from the apex was by Protaper system with Endoactivator irrigation shown in figure (3-1) .

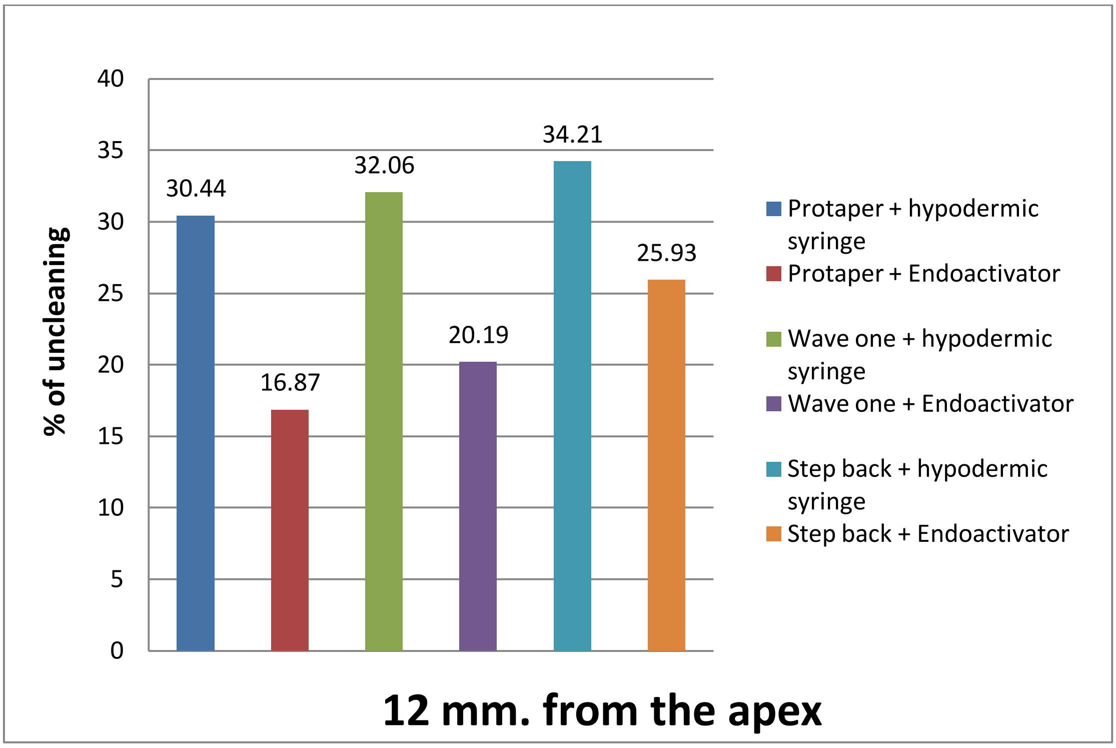


Figure (3-1) Chart of the percentage of unclean root canals surface area at 12mm from the apex.

The least uncleaned root canal surface area at 6 mm from the apex was by Protaper system with Endoactivator irrigation shown in figure (3-2) .

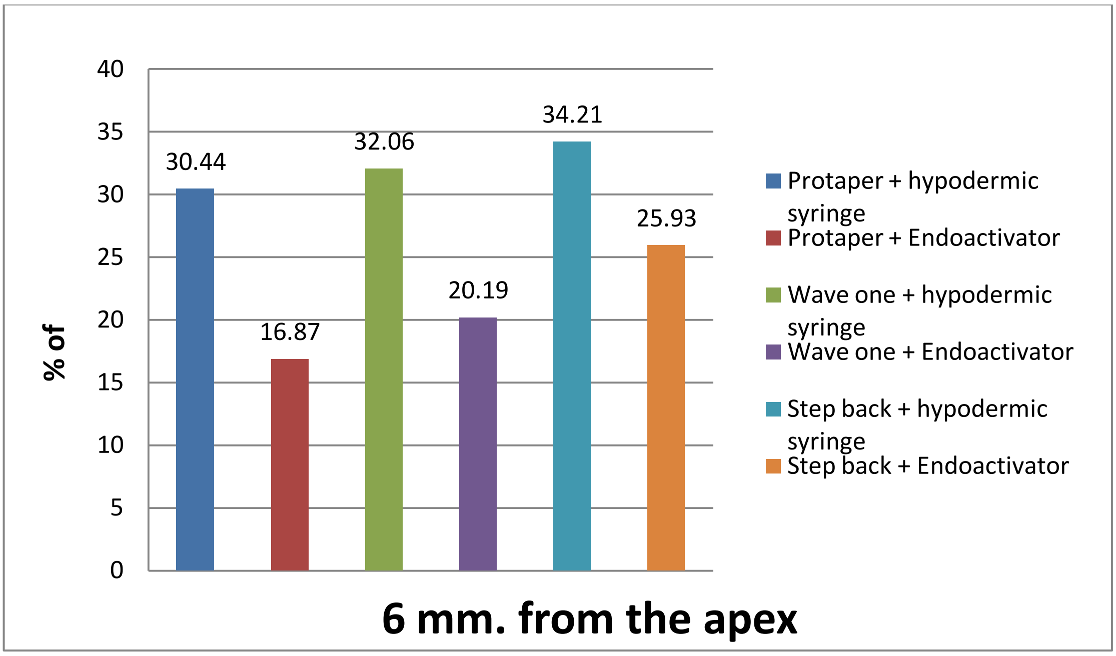


Figure (3-2) Chart of the percentage of unclean root canals surface area at 6mm from the apex.

The least uncleaned root canal surface area at 2 mm from the apex was by Protaper system with Endoactivator irrigation shown in figure (3-3) .

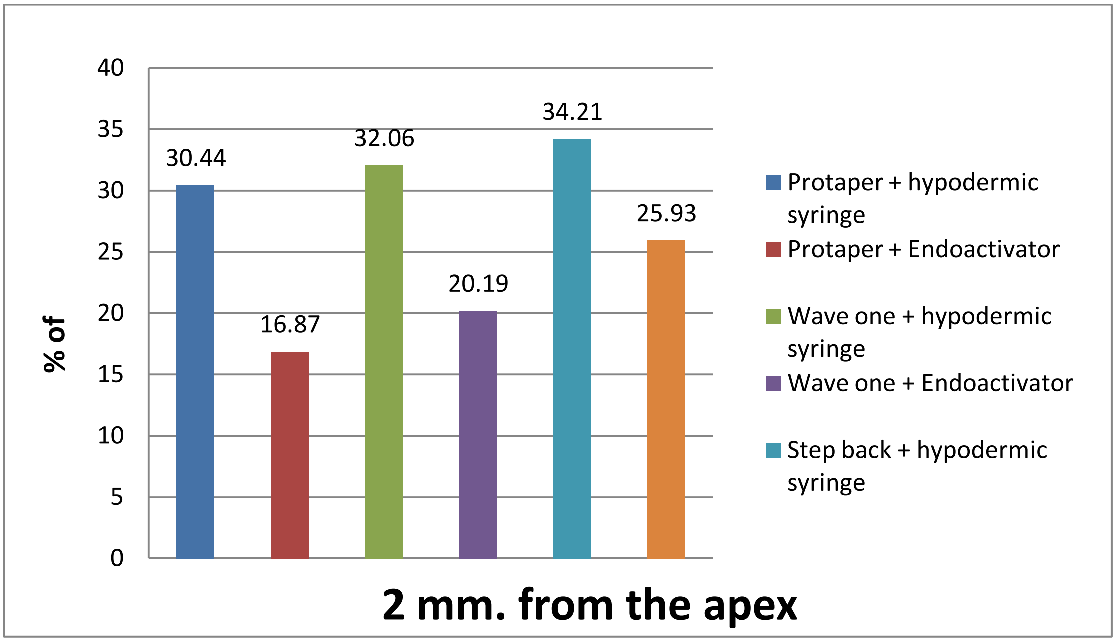


Figure (3-3) Chart of the percentage of unclean root canals surface area at 2mm from the apex.

3.2. The comparison among the six groups in the percentage of unclean isthmus surface area after instrumentation.

Data in the second study represent the percentage of the unclean isthmus area after instrumentation by different rotary instruments with different irrigation systems at three sections (12 mm from apex, 6 mm from apex and 2 mm from the apex).

The comparison among groups in the least uncleaned surface at each section was the mean of each group the lowest mean the best cleaned isthmus surface area is shown in table (3-2).

The least uncleaned isthmus area according to preparation techniques was Protaper system ,and according to the irrigation systems was EndoActivator system.

Table (3-2) The means of percentage of the unclean isthmus area at 12mm,6mm,2mm from the apex .

Sections	Group 1 A	Group 1B	Group 2A	Group4 2B	Group 3A	Group 3B
canal orifice (12mm from apex)	30.38	16.72	32.44	20.52	32.82	25.72
6 mm from apex	21.72	14.36	18.3	15.5	23.93	22.8
3 mm from apex	13.25	9.55	14.35	12.13	18.33	17.75

The least uncleaned isthmus surface area at 12 mm from the apex was by Protaper system with Endoactivator irrigation figure(3-4).

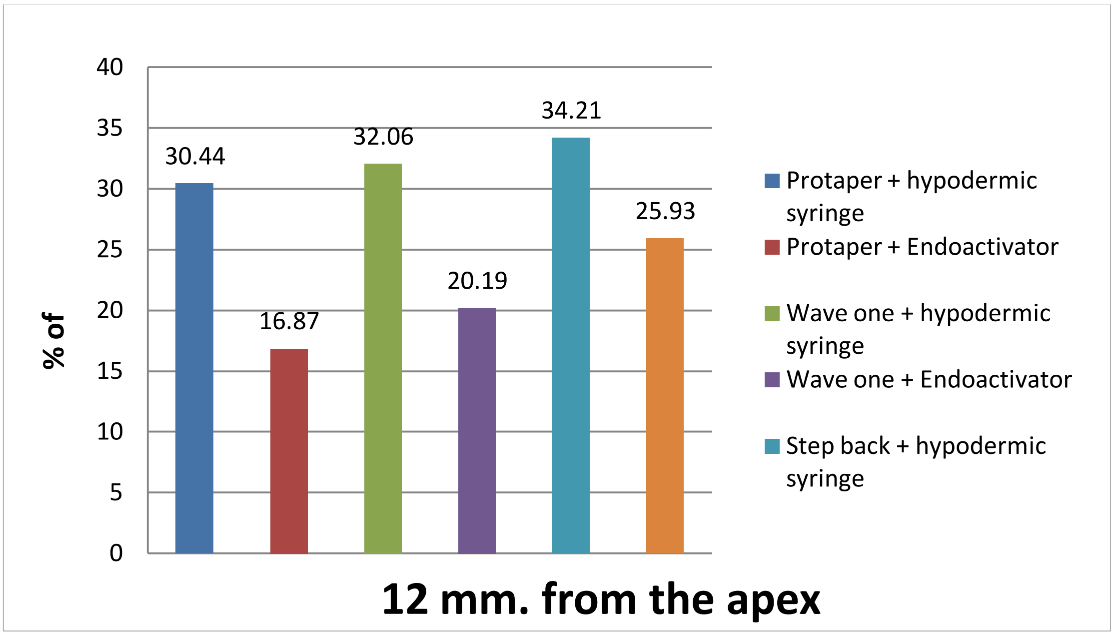


Figure (3-4) Chart of the percentage of unclean isthmus surface area at 12 mm from the apex.

The least uncleaned isthmus surface area at 6 mm from the apex was by Protaper system with Endoactivator irrigation figure(3-5).

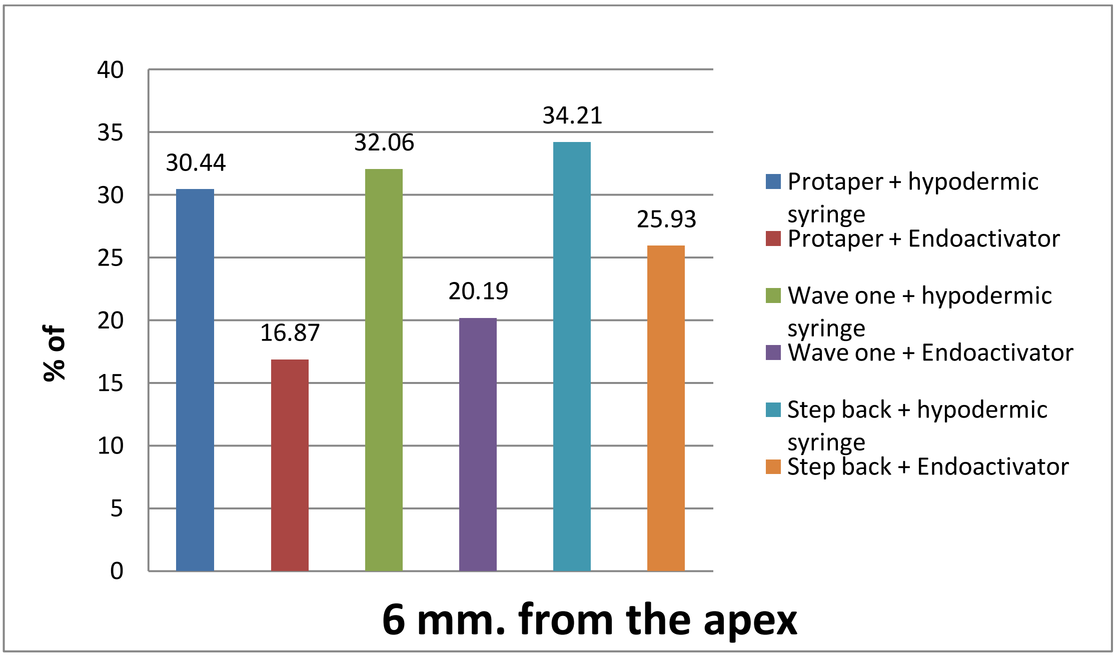


Figure (3-5) Chart of the percentage of unclean isthmus surface area at 6 mm from the apex.

The least uncleaned isthmus surface area at 2 mm from the apex was by Protaper system with Endoactivator irrigation figure(3-6).

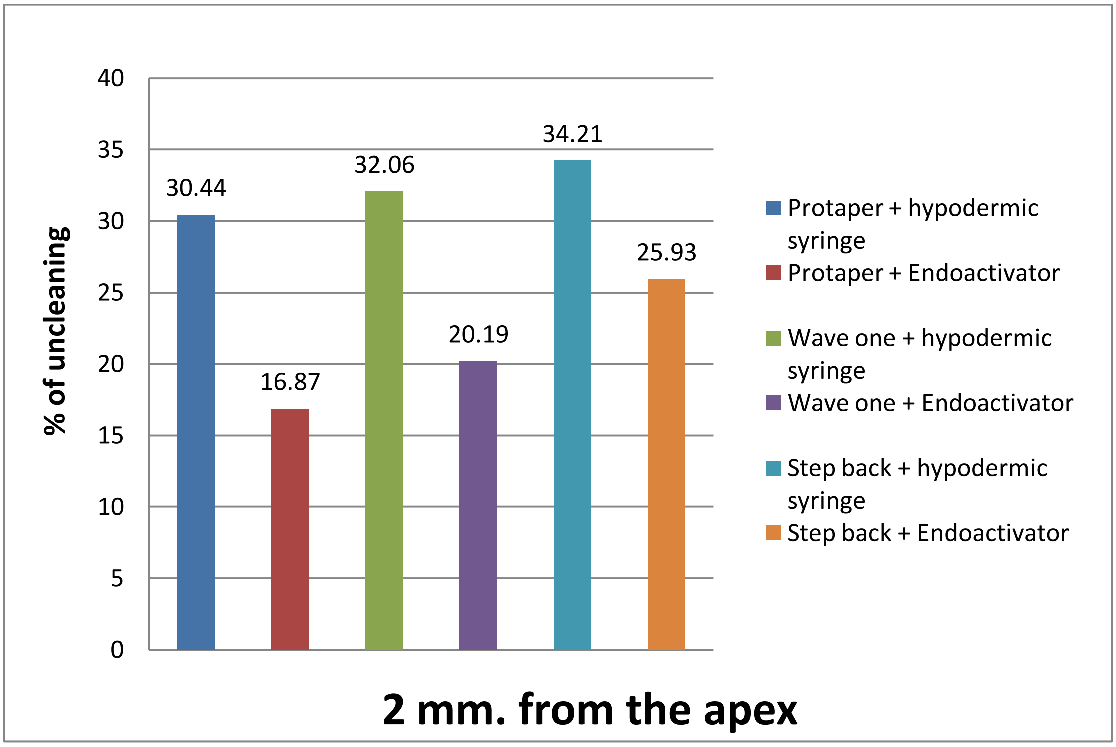


Figure (3-6) Chart of the percentage of unclean isthmus surface area at 6 mm from the apex.

3.3.The comparison among the Protaper, Wave One and step back systems

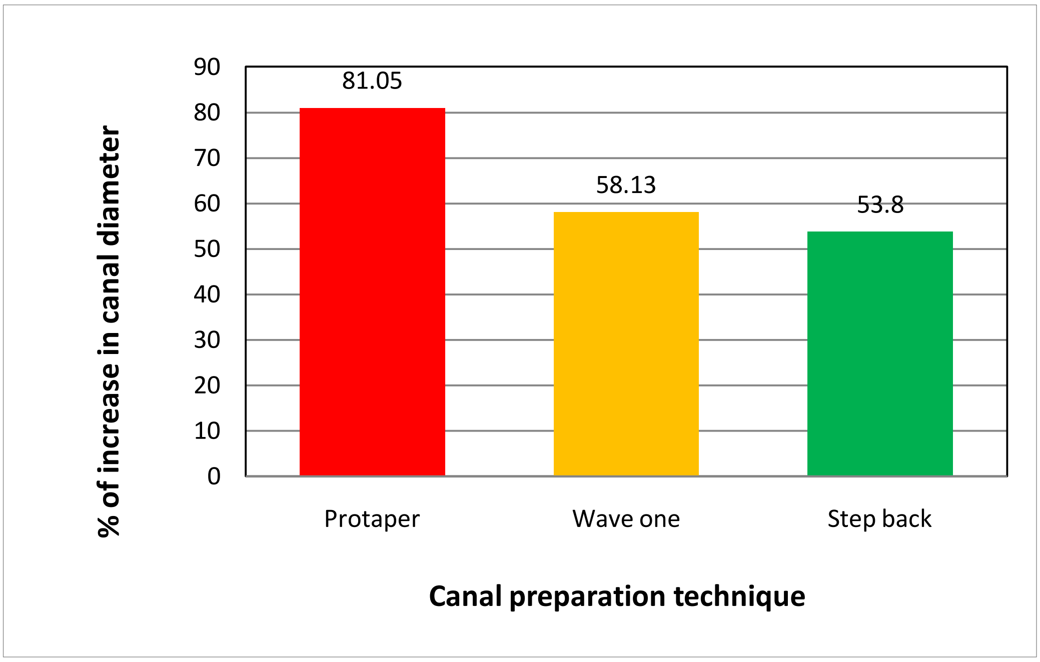
3.3.1. In the percentage of increase root canals diameter after instrumentation at the orifice area.

The data of the first part of the third study is the percentage of increase in canal diameter by using different rotary instrumentation systems at the root canal orifice is shown in table (3-3).

Table (3-3) The means of the percentage of increase in canal diameter at the canal orifice area.

Canal preparation techniques	Mean
Protaper	81.05
Wave one	58.13
Step back	53.80

The highest percentage of increase canal diameter was Protaper, then Wave One, then step back technique figure (3-7).



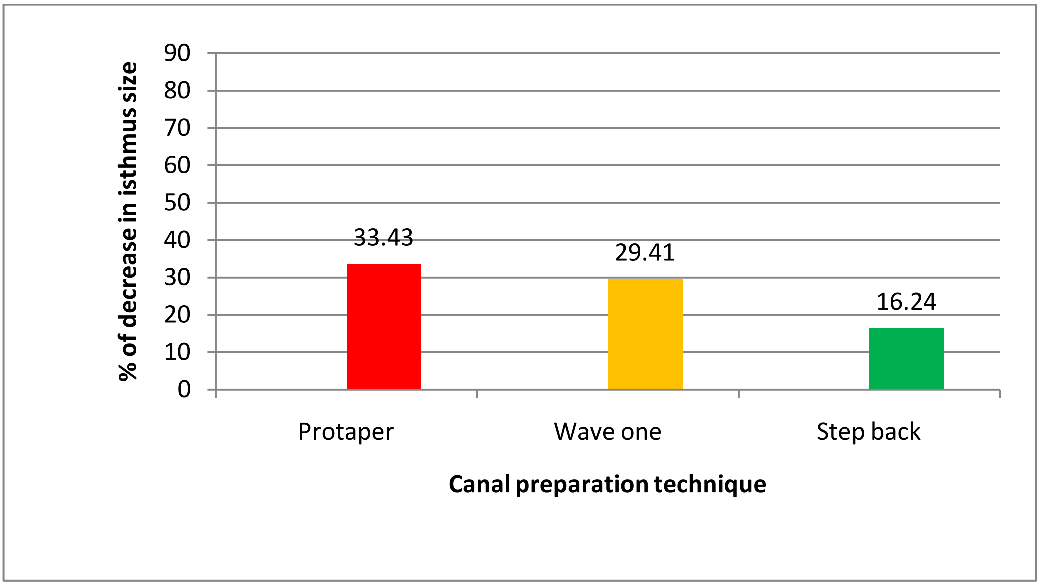
3.3.2. In the percentage of decrease isthmus size after instrumentation.

The data of the second part of the third study on the percentage of decrease isthmus size by using different rotary systems at the root canal orifice is shown in table (3-4).

Table (3-4) The means of the percentage of decrease in isthmus size at the canal orifice area.

Canal preparation techniques	Mean
Protaper	33.43
Wave one	29.41
Step back	16.24

The highest percentage of decrease isthmus size was Protaper, then Wave One, then step back technique figure (3-8).



Discussion

4.1. The comparison among the six groups in the percentage of unclean root canals surface area after instrumentation at 12 mm, 6 mm and 2 mm sections from apex.

- At the 12mm,6 mm from the apex: The least un-clean surface area of root canal at coronal section was the Protaper system with endoactivator group, followed by Wave One with endoactivator, then Protaper with hypodermic syringe, then Wave One with hypodermic syringe, then stepback with endoactivator and lastly stepback with hypodermic syringe**.**

This may be due to the use of multiple instruments (5 files) during the Protaper preparation and brushing action against canal wall, while only 2 files were used during Wave One preparation.

The result was best by using endoactivator system than without it. This may be due to the acoustic streaming due to sonic activation to irrigation fluid.

The result of this study at 12mm,6mm agrees with the finding of Burklein et.al 2012, which showed that the Protaper system removes more smear layer and cleans better than Wave One. The finding of Rodig et.al 2010 agrees with the present study as it shows more smear layer removal at coronal region is effective when endoactivator system was used.

Also the result of the study at 6mm agree with The finding of Luciana et.al 2011 showed that sonic irrigation is better in smear layer removal middle third of the canal than conventional irrigation which agree with this study. Uma et.al in 2010 got comparable result with this study when they found that endoactivator better cleaned the middle third of the canal from debris.

- At 2 mm section from the apex: The least un-clean surface area of root canal at the 2 mm section from the apex was Protaper system with endoactivator, followed by Wave One with endoactivator, then stepback with endoactivator, after that Protaper with hypodermic syringe, then stepback with hypodermic syringe and lastly Wave One with hypodermic syringe.

The result was best by using endoactivator system than without it which may be due to acoustic streaming due to sonic activation to irrigation fluid. This study agrees with the finding of Burklein et.al 2012 in the apical part, who showed Protaper system removes more smear layer and cleans better than Wave One. The finding of Rodig et.al 2010 showed more smear layer removal at apical region is effective when endoactivator system was used.

This study agrees with the finding of Luciana et.al 2011 who showed sonic irrigation is better in smear layer removal apical third of the canal than conventional irrigation. Luiz et.al 2011 showed that none of hand or rotary instrument was totally effective in cleaning apical root canals space. There is an agreement with the finding of Uma et.al 2010 who presented that the endoactivator better cleaned the apical third of the canal from debris.

4.2. The comparison among the six groups in the percentage of unclean isthmus surface area after instrumentation at 12 mm, 6 mm, and 2 mm sections from apex.

- At coronal section (12 mm from the apex): The least un-clean surface area of isthmus at coronal section was Protaper system with endoactivator, followed by Wave One with endoactivator, then stepback with endoactivator, then Protaper system with hypodermic syringe, then Wave One with hypodermic syringe and lastly step back with hypodermic syringe.

This result agrees with Gencoglu and Gundogar 2008 who showed ultrasonic instrument is useful to clean isthmus of mesial root of mandibular molars which supports the use of endoactivator system. This study disagrees with Mathew 2012 who presented Wave One is the worst in isthmus cleaning. The present findings agree with of Susin et.al 2010 that no irrigation techniques produce completely removed debris from isthmus regions. The result of Protaper system with hypodermic syringe is 30.44% of unclean isthmus area more debris removal and accumulation in isthmus which is removed by using endoactivator, the debris were dislodged and removed resulting in better cleaning.

- At 6 mm section from the apex: The least un-clean surface area of isthmus at 6 mm section from the apex was Protaper with endoactivator, followed by Wave One with endoactivator, then Protaper system with hypodermic syringe, then stepback with endoactivator, then Wave One with hypodermic syringe and lastly step back with hypodermic syringe. This result agrees with Gencoglu and Gundogar 2008 who showed ultrasonic instrument was useful to clean isthmus of mesial root of mandibular molars which supports the use of endoactivator system. Unni et.al 2011 supported the present study's findings that rotary system with endoactivator never reached 100% cleaning. The finding of Susin et.al 2010 presented that no irrigation technique produce completely removed debris from isthmus regions. This study disagrees with Mathew 2012 who showed that Wave One is the worst in isthmus cleaning.

- At 2 mm section from the apex: The least un-clean surface area of isthmus at 2 mm section from the apex was Protaper with endoactivator, followed by Wave One with endoactivator, then Protaper system with hypodermic syringe, then Wave One with hypodermic syringe, then stepback with endoactivator and lastly step back with hypodermic syringe.

This result agrees with Gencoglu and Gundogar 2008 who showed ultrasonic instrument was useful to clean isthmus of mesial root of mandibular molars which supports the use of endoactivator system. Unni et.al 2011 supported the present study's findings that rotary system with endoactivator never reached 100% cleaning. The finding of Susin et.al 2010 presented that no irrigation technique produce completely removed debris from isthmus regions .This study disagrees with Mathew 2012 who showed that Wave One is the worst in isthmus cleaning.

4.3.The comparison among the Protaper, Wave One and step back systems

4.3.1. In the percentage of increase root canals diameter after instrumentation.

The percentage of increase in root canal diameter which is highest by using rotary Protaper system followed by Wave One system, then step-back system.The diameter of primary Wave One file at 12 mm from apex is 1.05 mm, Protaper F2 file start by 0.08% taper then taper decrease coronaly which make instrument stiff and cutting more which diameter reached 1.05 at 12mm, while size 90 k-file has 0.92 mm diameter at canal orifice which is least diameter among the other two instruments which may explain the least canal diameter by step back technique.

The Protaper system used five instruments during preparation and by brushing action during instrumentation may result in more dentine removal at the canal orifice producing the largest increase in canal diameter, while Wave One used two instruments during preparation.

This finding agrees with the finding by Bernardes et.al 2010 who found that Protaper system significantly increased the root canal area at all levels.

4.3.2. In the percentage of decrease isthmus area after instrumentation.

The percentage of decreasing isthmus area by using different rotary instrumentation techniques including Protaper system, Wave One and stepback techniques showed that the best result of the decreasing the percentage of isthmus area was by Protaper system followed by Wave One then stepback. This was the first study to measure the isthmus area before and after instrumentation therefore measuring the extension of preparation to the isthmus area; the variation in this study may be explained by the presence of normal variation in the area of the isthmus.

The diameter of primary Wave One file at 12 mm from apex is 1.05 mm, Protaper F2 file start by 0.08% taper then taper decrease coronaly which make instrument stiff and cutting which diameter reached 1.05 at 12mm , while size 90 k-file has 0.92 mm diameter at canal diameter which results in least canal diameter among the other then least decrease isthmus area.

The Protaper system used five instruments during preparation and by brushing action during instrumentation may result in more dentine removal at the canal orifice resulting in the largest increase in canal diameter, while Wave One using two instrument during preparation.

5.1 Conclusions:

1- The best cleaning result for root canal walls 12 mm, 6 mm and 2 mm from the apex were the Protaper system, then Wave One system and lastly the step back technique.

2- The Endoactivator irrigation system presented better results than the manual hypodermic syringe when used with all the instrumentation systems.

3- The best cleaning result for isthmus walls cleaning 12 mm, 6 mm and 2 mm from the apex were the Protaper system, then Wave One system and lastly the step back technique.

4- Maximum coronal orifice widening was presented in the Protaper system, followed by Wave One system, then step back system.

5- The system that performed maximum decreasing in the isthmus area after instrumentation was the Protaper system, followed by Wave One system, then step back system.

5.2 Suggestions:

- The use of other types of the rotary system to measure the isthmus cleaning.
- Evaluation of isthmus cleaning using different irrigation systems and materials.
- The use of methods to measure the cleaning of isthmus (CT-Scan,M.CT).

References

A

- **Azorit C, Hervas J, Analla M, Carrasco R, Mun oz-Coho J.** Histological Thin-Sections: a Method for the Microscopic Study of Teeth in Spanish Red Deer (Cervus elaphus hispanicus)**,** Anatomia, Histologia, Embryologia. 2002; 31: 4: 224–227.

B

- **Bancroft JD, Stevens A.** Theory and practice of histological techniques. 3rd edition, Churchill livingstone inc., Edinburgh. London, Melbourne and New York **1990**;1-7, 32-33.
- **Bernardes RA, Rocha EA, Duarte MA, Vivan RR, de Moraes IG, Bramante AS, de Azevedo JR**. Root canal area increase promoted by the EndoSequence and ProTaper systems: comparison by computed tomography. J Endod. 2010;36(7):1179-82
- **Boutsioukis C, Lambrianidis T, Kastrinakis E.** Irrigant flow within a prepared root canal using various flow rates: a computational fluid dynamics study, Int Endod J. **2009**;42:144–55.
- **Brkanić T,Ivana S,Vukoje K, Živković S.**Scanning electron microscopy investigation of canal cleaning after canal preparation with nickel titanium files, Srp Arh Celok Lek. **2010** ;138(9-10):551-6.
- **Brkanić T, Stojšin I, Živković S, Vukoje K.** Canal wall thickness after preparation with NiTi rotary files, Microsc Res Tech **.2012** ;75(3):253-7.
- **Buchanan LS.** Paradigm shifts in cleaning and shaping, Calif Dent Assoc J .**1991**;19:23.
- **Bürklein S, Hinschitza K, Dammaschke T**. Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of

extracted teeth: Reciproc and WaveOne versus Mtwo and ProTaper, Schäfer E. Int Endod J. **2012** ; 45(5):449-61.

C

- **Cambruzzi JV, Marshall FJ**. Molar endodontic surgery, Journal of Canadian Dental Assoc **.1983**; 49:616
- **Caron G.** Cleaning efficiency of the apical millimeters of curved canals using three different modalities of irrigant activation: an SEM study, Master's Thesis, Paris VII, Paris, France, publication pending **2007**.
- **Caron G, Nham K, Bronnec F, Machtou P.** Effectiveness of different final irrigant activation protocols on smear layer removal in curved canals Endodontic J. 2010 Aug;36(8):1361-6.
- **Ciucchi B, Cergneux M, Holz J.** Comparison of curved canal shape using filing and rotational instrumentation techniques, International Endodontic Journal. **1990**; 23: 3: 139–147.
- **Clem WH.** Endodontics in the adolescent patient, Dent Clin North Am **1969**. 13:483.
- **Clifford J R.** Endodontic canal preparation: waveone single-file technique, Dentistry today. **2012**;32:2:4-7 .
- **Clifford J R**. Endodontic Disinfection Tsunami Irrigation, Endodontic Practice .2008;11:1:7-15 .
- **Clifford J R.** The protaper advantage: shaping the future of endodontics, Dentistry today .**2001**;21:2: 1-5.
- **Coffae KP, Brilliant JD.** The effect of serial preparation versus nonserial preparation on tissue removal in the root canals of extracted mandibular human molars, J Endod**. 1975**; (6):211.

D

- **Desai P, Himel V**. Comparative safety of various intracanal irrigation systems, J Endod. **2009**; 35(4):545-9.

F

- **Fan B, Pan Y, Gao Y, Fang F, Wu Q, Gutmann J L.**Three-dimensional morphologic analysis of isthmuses in the mesial roots of mandibular molars, J Endod **.2010** ;36(11):1866-9.

G

- **Gencoglu N, Gundogar M.**Cleaning Effect of Ultrasonic Debridement on Isthmus in Mandibular Molars, Marmara University, Istanbul, Turkey, Queen Elizabeth II Conference Centre Poster Hall 1the Pan European Federation of the International Association for Dental Research (September 10-12, **2008**).
- **Green D.** Double canals in single roots, Oral Surg **.1973**; 35:689.
- **Guerisoli DM, Marchesan MA, Walmsley AD, Lumley PJ, Pecora JD.** Evaluation of smear layer removal by EDTAC and sodium hypochlorite with ultrasonic agitation, Int Endod J. **2002**; 35:5: 418-421.
- **Gu LS, Ling JQ, Huang XY, Wei X, Xu Q.** Amicro-computed tomographic study of the isthmus in the root canal system of mandibular first molar, Zhonghua Kou Qiang Yi Xue Za Zhi .**2009** ;44(1):11-4.

H

- **Hsu YY, Kim S.** The resected root surface: The issue of canal isthmuses, Dent Clin North Am. **1997** ; 41(3):529-40.

I

- **Ingle J, Backland K.** Endodontics, 5th Edition**,** BC Decker Inc ,Hamilton London . **2002**; 544-46.

J

- **John Haidet, Al Reader, Mike Beck, William Meyers.** An in vivo comparison of the step-back technique versus a step-back/ultrasonic technique in human mandibular molars, Journal of Endodontics. **1989**;15:195.
- **Julian Webber, Pierre Machtou , Wilhelm Pertot, Sergio Kuttler, Clifford Ruddle & John West .**The WaveOne single-file reciprocating system roots. 2011 ;1: page 28

K

- **Karpagaselvi Sanjai, Jayalakshmi Kumarswamy, Archana Patil, Lokesh Papaiah, Srinivas Jayaram, Lakshmi Krishnan.** Evaluation and comparison of decalcification agents on the human teeth, JOMFP.**2012**; 16: 2 : 222-227.
- **Kim HC, Hwang YJ, Jung DW, You SY, Lee W.** Micro-computed tomography and scanning electron microscopy comparisons of two nickel-titanium rotary root canal instruments used with reciprocating motion**,** Scanning **.2013**; 35(2):112-8.

L

- **Letters S, Smith AJ, McHugh S, Bagg J.** A study of visual and blood contamination on reprocessed endodontic files from general dental practice, Br Dent J **.2005**; 199:8: 522-525.
- **Lillie RD.** Histopathologic technique and practice histochemistry, 3rd edition, McGraw Hill Book co., New York. **1965**; 42-43,61-62,80-81.
- **Luciana Magrin Blank-Gonçalves, Cleber Keiti Nabeshima, Guilherme Henrique Rosa Martins, Manoel Eduardo de Lima Machado.** Qualitative analysis of the removal of the smear layer in the

apical third of curved roots: conventional irrigation versus activation systems.Journal of endodontics .2011; 37(9):1268-71

- **Luiz Fernando Machado Silveira, Juliana Kutter Bosembecker, Josué Martos,Carmen Maria Ferrer-Luque**. The quality of apical preparation in curved root canals using hand and rotary instrumentation techniques. Arch Oral Res. 2011;7(3):231-7
- **Lumley PJ**. Cleaning efficacy of two apical preparation regimens following shaping with hand files of greater taper, Int Endod J .**2000** ; 33(3):262-5.

M

- **Manisha Choudary T, Kiran C.** Isthmuses of the mesial root of mandibular first molar - A spiral computed tomographic study, Indian Endodontic Society. **2010**; 22 :1: 46-50.
- **Mannocci F, Peru M, Sherriff M, Cook R, Pitt Ford T R.**The isthmuses of the mesial root of mandibular molars: a micro-computed tomographic study, International Endodontic Journal. 2005; 38: 558-563.
- **Mathieu Goldberg, Sandrine Dahan, PierreMachtou.**Centering Ability and Influence of ExperienceWhen Using WaveOne Single-File Technique in Simulated Canals, International Journal of Dentistry. **2012;** 2012: 7.
- **Matthew A Dietrich, Timothy C Kirkpatrick, and John M Yaccino**. In Vitro Canal and Isthmus Debris Removal of the Self-Adjusting File, K3, and WaveOne Files in the Mesial Root of Human Mandibular Molars, J Endod .**2012**;38:1140–1144.
- **Mullaney T**. Instrument of finely curved canals, Dent Clin North Am. **1979**; 4:575.

P

- **Paqué F, Musch U, Hülsmann M**. Comparison of root canal preparation using RaCe and ProTaper rotary Ni-Ti instruments, Int Endod J. **2005**;38(1):8-16.
- **Paragliola R, Franco V, Fabiani C, Mazzoni A**, **Mazzoni A, Nato F, Tay FR, Breschi L, Grandini S.** Final rinse optimization: influence of different agitation protocols, J Endod. **2010**; 36(2):282-5.
- **Pineda F**. Roentgenographic investigation of the mesiobuccal root of the maxillary first molar, Oral Surg **1973;** 36:253.
- **Pitt Ford TR, Rhodes JS, Pitt Ford HE.** Endodontics Problem-Solving in Clinical Practice, 1st Edition, Martin Dunitz Ltd, The Livery House, 7-9 Pratt Street, London NW1 OAE **.2002**;79,107-8.
- **Pitt WG.** Removal of oral biofilm by sonic phenomena, Am J Dent. **2005**; 345-352.

R

- **Richard Archer, Al Reader, Robert Nist, Beck M, Meyers WJ**. An in vivo evaluation of the efficacy of ultrasound after step-back preparation in mandibular molars, Journal of Endodontics **1992**; 18: 11: 549-552.
- **Richard E Walton, Mahmoud T.** Principles and Practice of Endodontics. 3rd Edition, W.B. Saunders Company, Copyright **2002**.
- **Rödig T, Döllmann S, Konietschke F, Drebenstedt S, Hülsmann M**. Effectiveness of different irrigant agitation techniques on debris and smear layer removal in curved root canals: a scanning electron microscopy study, J Endod .**2010**; 36(12):1983-7.

S

- **Schilder H.** Cleaning and shaping the root canal, Dent Clin North Am.1974;18:269

- ❖ **Sedgley CM, Nagel AC, Hall D, Applegate B**. Influence of irrigant needle depth in removing bioluminescent bacteria inoculated into instrumented root canals using real-time imaging in vitro, Int Endod J. **2005**;38:97–104.
- ❖ **Singla M, Aggarwal V, Logani A, Shah N**. Comparative evaluation of rotary ProTaper, Profile, and conventional stepback technique on reduction in Enterococcus faecalis colony-forming units and vertical root fracture resistance of root canals, Oral Surg Oral Med Oral Pathol Oral Radiol Endod.**2010** ;109(3):105-10.
- ❖ **Siqueira JF Jr.** Aetiology of root canal treatment failure: why well treated teeth can fail, Int Endod J **.2001**;34:1–10.
- ❖ **Siqueira JF Jr, Araújo MC, Garcia PF, Fraga RC, Dantas CJ.** Histological evaluation of the effectiveness of five instrumentation techniques for cleaning the apical third of root canals. J Endod. 1997;23(8):499-502.
- ❖ **Skidmore AE, Bjørndal AM.**Root canal morphology of the human mandibular first molar, Oral Surg Oral Med Oral Pathol **.1971**; 32(5):778-84.
- ❖ **Stanley J Nelson**, Weeler s dental anatomy, physiology and occlusion, the permanent mandibuller moller. 9th edition, Saunders Elsevier **2010**; chap. 12 :260-264.
- ❖ **Stephen Cohen, Richard C Burns**.Pathway of the pulp.8th Edition, Copyright by Mosby Inc. **2002**; 244-245.
- ❖ **Susin L, Liu Y, Yoon JC, Parente JM, Loushine RJ, Ricucci D, Bryan T, Weller RN, Pashley DH, Tay FR.** Canal and isthmus debridement efficacies of two irrigant agitation techniques in a closed system. Int Endod J. 2010 ;43(12):1077-90.

T

- **Teixeira FB, Sano CL, Gomes BP, Zaia AA, Ferraz CC, Souza-Filho FJ.** A preliminary in vitro study of the incidence and position of the root canal isthmus in maxillary and mandibular first molars, Int Endod J. **2003**;36(4):276-80.
- **Townsend C, Maki J**. An in vitro comparison of new irrigation and agitation techniques to ultrasonic agitation in removing bacteria from a simulated root canal, J Endod. **2009**; 35(7):1040-3.

U

- **Uma P Nair,Marianella N,Kevin K,Prathibha P,Claudio H,RobertaP.** Comparative evaluation of three different irrigation activation on debris removal from root canal systems**.**Revista Presei Medicale Internationale .2011**;**1:67-70
- **Unni Endal,Ya Shen,Arving Knut, Yuan Gao,and Markus Haapasalo**. A High-resolution Computed Tomographic Study of Changes in Root Canal Isthmus Area by Instrumentation and Root Filling , J. Endod. **2011**;37:223–227.

V

- **Vertucci FJ.** Root canal anatomy of the human permanent teeth, Oral Surgery, Oral Medicine, Oral Pathology. **1984**; 58: 5: 589–599.
- **Von Arx T.** Frequency and type of canal isthmuses in First molars detected by endoscopic inspection during periradicular surgery, Int Endod J **.2005**; 38(3):160-8.

W

- **Weine FS, Pasiewicz RA, Rice RT.**Canal configuration of the mandibular first molar using a clinically oriented in vitro method . Journal of Endodontics. 1988;14:207–13.

Y

- **Young-Sil Yoo and Yong-Bum Cho .** A comparison of the shaping ability of reciprocating NiTi instruments in simulated curved canals. Restorative dentistry and Endodontics .2012;37:4.220

Appendix 1 : percentage of increased in canal diameter by Protaper system.

Protaper system			
Root canals	**Before**	**After**	**% of increased canal diameter**
R 1	0.7	1.5	114.29
R 2	0.7	1.25	78.57
R 3	0.7	1.5	114.29
R 4	0.6	1	66.67
R 5	1.25	1.65	32.00
R 6	1.05	1.7	61.90
R 7	0.75	1.4	86.67
R 8	0.8	1.4	75.00
R 9	0.6	1	66.67
R10	0.65	1.35	107.69
R 11	0.75	1.4	86.67
R 12	0.6	1.25	108.33
R 13	0.6	1.35	125.00
R 14	0.65	1	53.85
R 15	1.35	1.55	14.81
R 16	0.85	1.45	70.59
R 17	0.65	1.3	100.00
R 18	0.7	1.3	85.71
R 19	0.9	1.15	85.71
R 20	0.75	1.4	86.67
Mean :	0.78	1.34	81.05

Appendix 2 : percentage of increased in canal diameter by Wave One system.

Wave One system			
Root canals	**Before**	**After**	**% of increased canal diameter**
R 1	0.8	1.4	75.00
R 2	1.14	1.5	31.58
R 3	0.7	1.15	64.29
R 4	1.05	1.45	38.10
R 5	0.8	1.15	43.75
R 6	0.7	1.4	100.00
R 7	0.7	1.29	84.29
R 8	0.84	1.35	60.71
R 9	0.9	1.39	54.44
R10	1.1	1.45	31.82

R 11	0.7	1.19	70.00
R 12	1.05	1.5	42.86
R 13	0.8	1.27	58.75
R 14	0.75	1.25	66.67
R 15	0.7	1.05	50.00
R 16	0.65	1.19	83.08
R 17	0.9	1.36	51.11
R 18	0.7	1.15	64.29
R 19	0.95	1.38	45.26
R 20	0.9	1.32	46.67
Mean	0.835	1.302	58.13

Appendix 3: percentage of increased in canal diameter by Step back system.

Step back system			
Root canals	**Before**	**After**	**% of increased canal diameter**
R 1	0.6	1.2	100.00
R 2	1.2	1.5	25.00
R 3	1.2	1.4	16.67
R 4	1.1	1.3	18.18
R 5	0.9	1.2	33.33
R 6	0.8	1.3	62.50
R 7	0.8	1.1	37.50
R 8	0.9	1.3	44.44
R 9	0.7	1.5	114.29
R10	0.8	1	25.00
R 11	0.7	1.3	85.71
R 12	1.1	1.4	27.27
R 13	0.8	1.3	62.50
R 14	0.6	1.1	83.33
R 15	1	1.3	30.00
R 16	0.7	1.2	71.43
R 17	0.9	1.2	33.33
R 18	0.9	1.1	22.22
R 19	0.7	1.4	100.00
R 20	0.6	1.1	83.33
Mean :	0.85	1.26	53.80

Appendix 4 : percentage of decreased isthmus size by Protaper system.

Protaper system : isthmus size			
Tooth number	**Before**	**After**	**% of decreasing in isthmus size**
1	1.7	1.5	13.33
2	1.05	0.9	16.67
3	2.55	2.15	18.60
4	0.9	0.6	50.00
5	2.65	2.55	3.92
6	2.85	2.05	39.02
7	2.8	2.3	21.74
8	2.2	1.15	91.30
9	2.35	1.7	38.24
10	2.9	2.05	41.46
Mean	2.19	1.69	33.43

Appendix 5 : percentage of decreased isthmus size by Wave One system.

Wave One : isthmus size			
Tooth number	**Before**	**After**	**% of decreasing in isthmus size**
1	2.85	2.7	5.56
2	2.5	2.35	6.38
3	1.45	0.75	93.33
4	1.5	1.25	20.00
5	1.8	1.55	16.13
6	2	1.2	66.67
7	1.3	1.25	4.00
8	2	1.9	5.26
9	2.45	1.8	36.11
10	2.25	1.6	40.63
Mean	2.01	1.63	29.41

Appendix 6 : percentage of decreased isthmus size by Step back system .

Step back : isthmus size			
Tooth number	**Before**	**After**	**% of decreasing in isthmus size**
1	1.4	1.2	16.67
2	2.5	2.3	8.70
3	1.9	1.7	11.76
4	2.2	1.9	15.79
5	2.1	2	5.00
6	1.8	1.6	12.50
7	2.4	2.2	9.09
8	1.4	1.2	16.67
9	2.4	1.5	60.00
10	1.7	1.6	6.25
Mean	1.98	1.72	16.24

الخلاصة

الهدف :

الهدف من الدراسة هو لتقييم المساحات السطحية لقناة الجذر نظيفة /غيرنظيفه بواسطة طريقة المقطع العرضي التشريحي المرضي لقناة الجذر و المضيق وتقييم درجة تحضير الأجهزة إلى المضيق باستخدام مختلف التقنيات والأجهزة الدوارة.

طرق التحضير:

تم تقسيم جذرالسن لثلاثين من اضراس الفك السفلي للإنسان في ستة مجموعات ، وتألفت كل مجموعة من خمسة جذور (10 قنوات جذر) .

المجموعة الاولى : باستخدام نظام بروتيبر وتحضر لحجم مبرد F2 وتغسل بمحلول ملحي باستخدام حقنة طبية.

المجموعة الثانية: باستخدام نظام بروتيبروتحضر لحجم مبردF2 وتغسل بمحلول ملحي باستخدام نظام اندواكتفيتر.

المجموعة الثالثة : باستخدام نظام الويف ون وتحضر بواسطة مبرد حجم صغير ثم مبرد حجم اولي وتغسل بمحلول ملحي باستخدام حقنة طبية .

المجموعة الرابعة : باستخدام نظام الويف ون وتحضر بواسطة مبرد حجم صغير ثم مبرد حجم اولي وتغسل بمحلول ملحي باستخدام نظام اندواكتفيتر.

المجموعة الخامسة: باستخدام نظام الستب باك وتحضر لحجم مبرد رقم 25 وتغسل بمحلول ملحي باستخدام حقنة طبية .

المجموعة السادسة : باستخدام نظام الستب باك وتحضر لحجم مبرد رقم 25 وتغسل بمحلول ملحي باستخدام نظام اندواكتفيتر.

جميع الجذور كانت مقطعة الى 12 مم من القمة ، 6 مم من القمة و 2 مم من القمة وثم درست بواسطة عرض المقطع العرضي التشريحي المرضي . وقد تم قياس درجة تنظيف كل قسم عن طريق استخدام برنامج اوتوكاد 2004.

النتائج:

افضل نظام تنظيف للمضيق في قسم الا كليلية والمتوسطة و القمي وجد من قبل نظام البروتيبرمع الا ندواكتفيتر النسبة المئوية للمساحة التي لم يتم تنظيفها هي للقمي 16.87 ٪ ، للمتوسطة14.32 ٪ والاكليلية 9.55 ٪. ثم نظام الويف ون مع الاندواكتفيتر ثم الأنظمة الأخرى .

افضل نظام تنظيف لجدار قناة الجذر في قسم الاكليلية والمتوسطة و القمي من قبل نظام البروتيبرمع الا ندواكتفيتر النسبة المئوية للمساحة التي لم يتم تنظيفها من 12.21 للقمي ٪ ، 9.14 للمتوسطة ٪ والاكليلية 18.55 ٪ ، ثم نظام الويف ون مع الا ندواكتفيتر ثم الأنظمة الأخرى . وكانت المقارنة المجموعات في أعلى نسبة في زيادة قطرالقناة وهو نظام بروتيبر ،ثم ويف ون ثم الستب باك . وكانت المقارنة بين المجموعات لإظهار أعلى نسبة في نقصان الحجم في منطقة المضيق وهو نظام بروتيبر ،ثم ويف ون ثم الستب باك

تم تحليل البيانات احصائيا باستخدام نظام فحص ANOVA و LSDو كروسكال والس H وبعده فحص مان ويتني U.

الاستنتاج:

نظام البروتيبرمع الاندواكتفيتر كان أفضل نظام في تنظيف القناة و المضيق.

دراسة لتقييم كفاءة تنظيف المضيق باستخدام مختلف تقنيات الأجهزة الدوارة

(دراسة في المختبر)

رساله مقدمة الى مجلس كلية طب الاسنان في جامعة بغداد

كجزء من متطلبات نيل درجة الماجستير

في معالجة الاسنان

من قبل

زهى اياد جابر

بكالوريوس طب وجراحة الفم والاسنان

بأشراف

الأستاذ الدكتور حسين فيصل الحويزي

ربيع الاول/1435 هجري

كانون الاول/ 2014 ميلادي