

# Effect of Different Access Cavity Designs and Instrumentation Techniques on the Thickness of Pericervical Dentin - A CBCT Study

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**Abstract:** Endodontically treated teeth are proved to be weaker than vital teeth and are known to present a higher risk of fracture when compared to the vital teeth. Access cavity preparation is the first and most important phase of root canal treatment. A well-designed access preparation with good instrumentation technique is essential to analyze the geometry of the canal before and after instrumentation and assessing the type of preparation of the root canal a non-invasive method Cone Beam Computed Tomography is used. Hence, attention should be paid to unnecessary dent in removal during endodontic treatment, in order to maintain the strength of the teeth. The conventional endodontic access cavity has many drawbacks and does not adhere to the main objectives of the access cavity preparation. Hence, this study was intended to evaluate the effect of different access cavity designs and instrumentation techniques on the preservation of peri cervical dentin. **Aim:** The purpose of this study is to evaluate the effect of two access cavity designs and two instrumentation techniques on thickness of peri-cervical dentin using CBCT. **Materials & Methodology:** Sixty extracted human teeth (single rooted mandibular central incisors) collected. The specimens were divided into four groups of fifteen teeth each (n=15). Access cavity are prepared by Conventional method and Incisal method. Group 1:- Conventional access cavity preparation and canal enlargement with Pro-taper file. Group 2:- Conventional access cavity preparation and canal enlargement with Wave one-gold. Group 3: Incisal access cavity preparation and canal enlargement with Pro-taper file. Group 4: Incisal access cavity preparation and canal enlargement with Wave one-gold. After the access cavity preparation and instrumentation the teeth were positioned in the template, and CBCT scan is taken. The peri-cervical dentin thickness is calculated and measured in four surfaces that is, facial, lingual, mesial, and distal for all the groups. **Results:** Results indicate that Incisal approach with wave gold reciprocating file preserved the pericervical dentin thickness. **Conclusion:** Results showed that Incisal approach with wave gold reciprocating file has preserved the pericervical dentin thickness.

**Keywords:** Conebeam computed tomography; Incisal approach; Pericervical dentin, Wave one gold.

## 1. Introduction

Endodontically treated teeth are proved to be weaker than vital teeth and are known to present a higher risk of fracture when compared to the vital teeth.<sup>[1]</sup> During the preparation, stress concentrations that originate from the contact of the endodontic instrument with the dentin may induce the formation of dentinal defects such as micro-cracks.<sup>[2]</sup> Conventional endodontic access cavity in anterior teeth is achieved through a cavity, made on incisal edge or even labial surface of the tooth. This design has many drawbacks and does not adhere to the main objectives of the access preparation as preservation of tooth structure in cervical portion of the tooth. It can result in increased removal of tooth structure from the central portion of the tooth which compromises the resistance of the tooth to fracture<sup>[3][4]</sup>. Recently, the focus is shifting toward the preservation of tooth structure in cervical portion of the tooth as this portion is considered to be most susceptible to fracture from occlusal forces. The dentin in this critical portion has been called as peri-cervical dentin (PCD) which extends 4 mm above and 4mm below the level of cemento-enamel junction

The modification in access design is the “incisal approach.” It provides straight line and unimpeded access to the apical

third of the root, reducing the risk of perforations and better preparation, especially in the apical third of the canal. It is beneficial for patients with limited mouth opening and preserves the mechanism of anterior guidance.<sup>[5]</sup>

Currently available rotary instrumentation systems designed with nickel and titanium, the Protaper™ Rotary System shaping (Sx, S<sub>1</sub> and S<sub>2</sub>), finishing (F<sub>1</sub>&F<sub>2</sub>) instruments as well as multi-tapers that range from 2 to 19% in a single instrument is widely used in clinical practice. This system exhibits greater flexibility at the tip and greater resistance at the base of each instrument, with cutting edges at a variable helical angle, which provides greater cutting power and leads to a lower screw effect.<sup>[6]</sup>

Recently Wave One Gold files with reciprocal action is specifically designed to work inclockwise (CW) and counter clockwise (CCW) direction with the aim of reducing torsional stress and therefore fracture of the files. The concept of the “single-file technique” was adopted by Dentsply to produce a more optimal, dedicated, safe, improved mechanical properties, extrude less debris and thoroughly clean the canal by reducing the bacterial count. Overall, reciprocating files are more resistant to fracture than are continuously rotating files. superior to rotary files<sup>[6]</sup>.

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Cone beam computed tomography has evolved into a promising tool in endodontic research, with the capacity to provide high-resolution images without altering the original image. It is a non-invasive method of analysing the geometry of the canal, determining the efficiency of shaping techniques, comparing the anatomical structure of the root canal before and after instrumentation and assessing the type of preparation of the root canal.<sup>[7]</sup>

## 2. Materials and Methods

### Source of data

Sixty freshly-extracted intact permanent Mandibular central incisors for the study were collected from the Department of Oral and Maxillofacial Surgery, P.M.N.M. Dental College & Hospital, Bagalkot.

### Materials used in the study:

- Airotor hand piece
- Rotary Protaper system files  $S_x$ ,  $S_1$ ,  $S_2$ ,  $F_1$  and  $F_2$  (Dentsply Maillefer, Switzerland)
- Wave one gold file primary (Dentsply Maillefer, Switzerland)
- 3% Sodium Hypochlorite (Vishal Dentocare Private Limited, India)
- 27 gauge side vented needle (Prime Dental RC, India)
- Normal saline
- 10 K File (Mani Stainless Steel K file 25mm, Japan)
- 15 K File (Mani Stainless Steel K file 25mm, Japan)
- Ruler
- Cone beam computed tomography

### Methods of Collection of Data

Non carious freshly extracted intact permanent mandibular central incisors teeth were collected and stored in 10% Formalin solution.

### Inclusion Criteria:

Non carious freshly extracted intact permanent mandibular central incisors teeth.

### Exclusion Criteria:

- Teeth with enamel defects.
- Mutilated teeth.
- Fractured teeth.

### Methodology

A total of sixty extracted human teeth (single rooted mandibular central incisors) were collected. The specimens were randomly divided into four groups of fifteen teeth each (n=15). Access cavity were prepared by conventional method and incisal method.

**Conventional access cavity procedure:**-The initial point of entry with the bur were made just above the cingulum with the bur angled parallel to the surface of the entry point. The orifice opening were performed for both the groups (group 1 and group 2).

**Incisal access cavity procedure:** -The initial point of entry of the bur were kept short of the incisal edge in the lingual

surface of the crown, with the bur being held parallel to the long axis of the tooth. The orifice opening were performed for the both groups. (Group 3 and group 4)

### **Group 1 Conventional access cavity preparation and canal enlargement with Pro-taperfile:**

Conventional cavity preparation and bio-mechanical preparation were done with Pro-taper files according to manufacturer instructions. The canals were enlarged till  $F_2$ . These files were instrumented for 15 teeth. After the access cavity preparation, the root canals were scouted with #10 K file and checked for patency. Working length were determined radiographically and Glyde path were established up to the working length with a #15 K file.

### **Group 2 Conventional access cavity preparation and canal enlargement with Wave one-gold:**

Conventional cavity preparation and bio-mechanical preparation were done with Wave one-gold. The canal were enlarged till primary file (25/0.8). These files were instrumented for 15 teeth. After the access cavity preparation, the root canals were scouted with #10 K file and checked for patency. Working length were determined radiographically and Glyde path were established up to the working length with a #15 K file.

### **Group 3 Incisal access cavity preparation and canal enlargement with Pro-taper file:-**

Incisal cavity preparation and bio-mechanical preparation were done with Pro-taper files according to manufacturer instructions. The canals were enlarged till  $F_2$ . These files were instrumented for 15 teeth. After the access cavity preparation, the root canals were scouted with #10 K file and checked for patency. Working length were determined radiographically and Glyde path were established up to the working length with a #15 K file.

### **Group 4 Incisal access cavity preparation and canal enlargement with Wave one-gold:-**

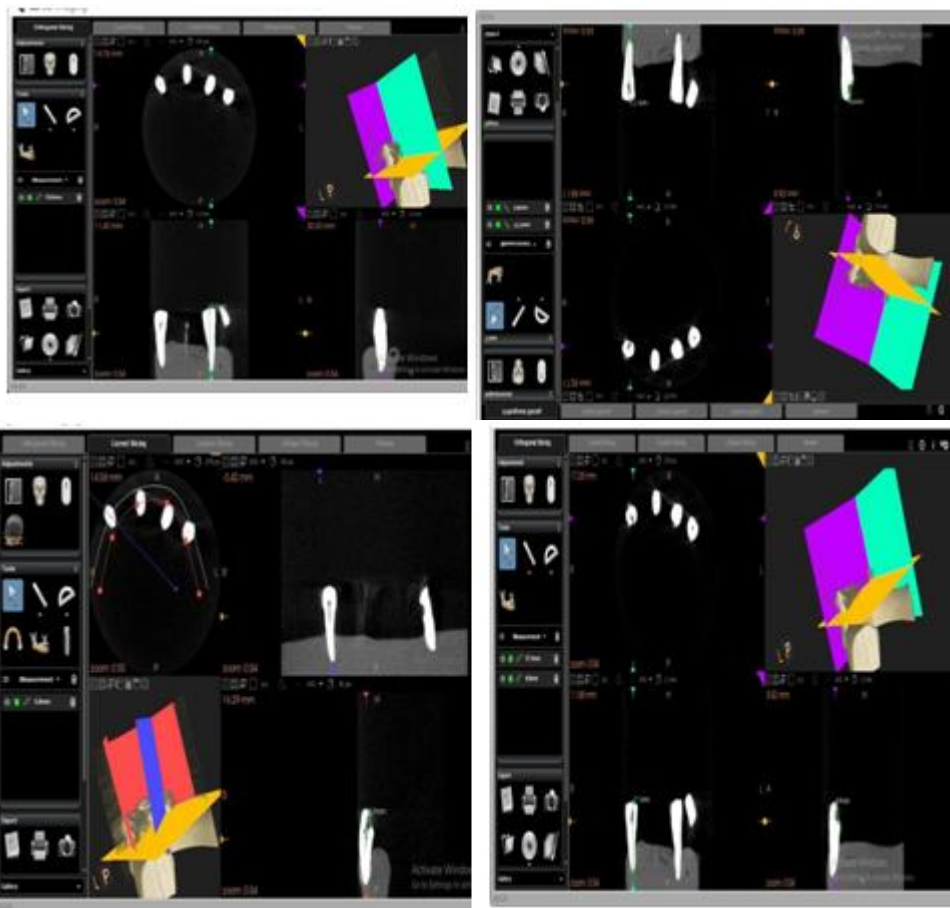
Incisal cavity preparation and bio-mechanical preparation were done with Wave one gold. The canal were enlarged till primary file (25/0.8). These files were instrumented for 15 teeth. After the access cavity preparation, the root canals were scouted with #10 K file and checked for patency. Working length were determined radiographically and Glyde path were established up to the working length with a #15 K file.

The root canals of all the samples were irrigated with 3% Naocl and saline, in between each instrument, delivered by 27 gauge needle, allowing for adequate back flow. Following instrumentation, the teeth were positioned in the template, and CBCT scan were taken.

The peri-cervical dentin thickness were calculated as the shortest distance from the canal outline to the closest adjacent root surface, which will be measured in four surfaces, that is, facial, lingual, mesial and distal for all the groups in the three obtained scans.

### Statistical Analysis:

The values will be analyzed by the use of ANOVA test analysis of variance (ANOVA) and paired sample T test.



### Sample Size Estimation

The samples have been estimated by using the Statistical Package for Social Sciences [SPSS] for Windows, Version 22.0. Released 2013. Armonk, NY: IBM Corp

### Descriptive Statistics:

Descriptive analysis includes expression of cervical dentin thickness in terms of mean and standard deviation for each group.



**Inferential Statistics:**

One-way ANOVA test followed by Tukey's HSD post hoc analysis was used to compare the mean Peri cervical dentin thickness and cervical dentin thickness with respect to facial, lingual, mesial and distal sides between four study groups during Pre-operative and Post-operative period. Student Paired t Test was used to compare the mean Peri cervical dentin thickness and cervical dentin thickness with respect to Facial, Lingual, Mesial and Distal sides between Pre-op and Post-op period in each study group. The level of significance [P-Value] was set at P<0.05.

**3. Results**

The Peri-Cervical dentin thickness during Pre-operative and Post-operative with respect to Facial, Lingual, Mesial and Distal sides between 4 study groups showed that Group 4 (4.009 ± 0.364) preserved maximum peri-cervical dentin than other groups.

This was followed by the group 2 (3.819 ± 0.321) where conventional access cavity preparation by using Wave one gold primary file.

Next, Group 3 (3.397 ± 0.249) showed lesser peri-cervical dentin thickness. Group 1(5.275 ± 0.426) showed least peri cervical dentin thickness strength among 4 groups. This mean difference in mean Peri cervical dentin thickness during pre-op period was not statistically significant between different study groups [P=0.62].

**Table 1**

Comparison of mean Peri cervical dentin CBCT measurement (in mm) between 4 groups during Pre-op period using One-way ANOVA Test						
Groups	N	Mean	SD	Min	Max	P-Value
Group 1	15	5.275	0.426	4.4	5.8	0.62
Group 2	15	5.087	0.374	4.6	5.7	
Group 3	15	5.105	0.432	4.2	5.82	
Group 4	15	5.181	0.481	4.4	6	

Comparison of mean Peri cervical dentin CBCT measurement (in mm) between 4 groups during Post-op period using One-way ANOVA Test						
Groups	N	Mean	SD	Min	Max	P-Value
Group 1	15	3.197	0.222	2.8	3.6	<0.001*
Group 2	15	3.819	0.321	3.28	4.4	
Group 3	15	3.397	0.249	3	3.8	
Group 4	15	4.009	0.364	3.2	4.4	

\* **Statistically Significant**

Multiple comparison of mean difference in Peri cervical dentin thickness during post-op period between 4 study groups showed that Group 4 showed significantly higher mean Peri cervical dentin thickness as compared to Group 1 and Group 3 at P<0.001. This was followed by Group 2 showing significantly higher dentin thickness as compared to Group 1 and Group 3 at P<0.001 and P=0.001 respectively. However, no significant difference was found between Group 1 and Group 3 [P=0.26] and between Group 2 and Group 4 [0.30].

**Table 2**

Comparison of mean cervical dentin thickness (in mm) from different sides b/w 4 groups during Pre-op period using One-way ANOVA Test							
Sides	Groups	N	Mean	SD	Min	Max	P-Value
Facial	Group 1	15	1.319	0.106	1.10	1.45	0.48
	Group 2	15	1.265	0.099	1.10	1.42	
	Group 3	15	1.270	0.104	1.05	1.45	
	Group 4	15	1.296	0.115	1.10	1.50	
Lingual	Group 1	15	1.319	0.106	1.10	1.45	0.48
	Group 2	15	1.265	0.099	1.10	1.42	
	Group 3	15	1.270	0.104	1.05	1.45	
	Group 4	15	1.296	0.115	1.10	1.50	
Mesial	Group 1	15	1.319	0.106	1.10	1.45	0.48
	Group 2	15	1.265	0.099	1.10	1.42	
	Group 3	15	1.270	0.104	1.05	1.45	
	Group 4	15	1.296	0.115	1.10	1.50	
Distal	Group 1	15	1.319	0.106	1.10	1.45	0.48
	Group 2	15	1.265	0.099	1.10	1.42	
	Group 3	15	1.270	0.104	1.05	1.45	
	Group 4	15	1.296	0.115	1.10	1.50	

\* - **Statistically Significant**

The test results demonstrated that mean Peri cervical dentin thickness with respect to different sides viz. Facial, Lingual, Mesial and Distal sides during post-op period between 4 groups with Group 1 having a thickness of 0.799 ± 0.056, Group 2 with 0.954 ± 0.080, Group 3 with 0.849 ± 0.062 and Group 4 having a mean thickness of 1.001 ± 0.091. This mean difference in mean Peri cervical dentin thickness with respect to different sides viz. Facial, Lingual, Mesial and Distal sides during post-op period between different study groups was statistically significant at P<0.001.

**Table 3**

Comparison of mean Peri cervical dentin thickness (in mm) b/w Pre-op and Post-op period in each study group using Student Paired t Test						
Groups	Time	N	Mean	SD	Mean Diff	P-Value
Group 1	Pre-op	15	5.275	0.426	2.077	<0.001*
	Post-op	15	3.197	0.222		
Group 2	Pre-op	15	5.087	0.374	1.268	<0.001*
	Post-op	15	3.819	0.321		
Group 3	Pre-op	15	5.105	0.432	1.707	<0.001*
	Post-op	15	3.397	0.249		
Group 4	Pre-op	15	5.181	0.481	1.173	<0.001*
	Post-op	15	4.009	0.364		

\* **Statistically Significant**

Multiple comparison of mean difference in Peri cervical dentin thickness with respect to different sides viz. Facial, Lingual, Mesial and Distal sides during post-op period between 4 study groups showed that Group 4 showed significantly higher mean Peri cervical dentin thickness as compared to Group 1 and Group 3 at P<0.001. This was followed by Group 2 showing significantly higher dentin thickness as compared to Group 1 and Group 3 at P<0.001 and P=0.001 respectively. However, no significant difference was found between Group 1 and Group 3 [P=0.26] and between Group 2 and Group 4 [0.30].

The test results demonstrated that the mean Peri cervical dentin thickness during post-op period was significantly reduced in Group 1 [3.197 ± 0.222], Group 2 [3.819 ± 0.321], Group 3 [3.397 ± 0.249] and Group 4 [4.009 ± 0.364].

0.364] as compared to Pre-op period in Group 1 [5.275 ± 0.426], Group 2 [5.087 ± 0.374], Group 3 [5.105 ± 0.432] and Group 4 [5.181 ± 0.481]. This mean reduction in Peri cervical dentin thickness in all the study groups was statistically significant at P<0.001.

**Table 4**

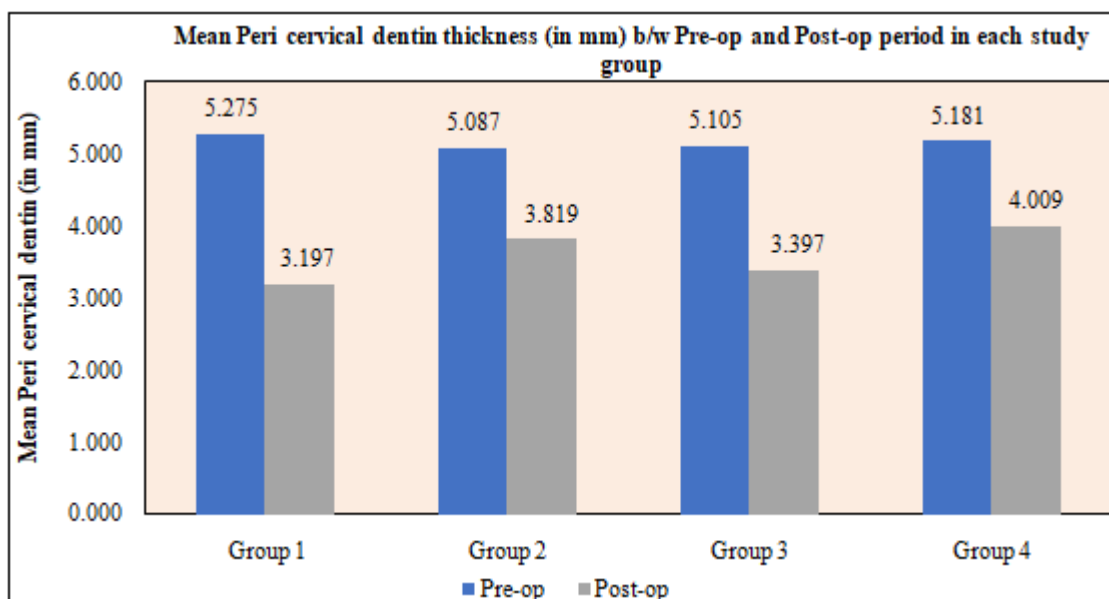
Comparison of mean Cervical dentin thickness (in mm) on Facial Side b/w Pre-op and Post-op period in each study group using Student Paired t Test						
Groups	Time	N	Mean	SD	Mean Diff	P-Value
Group 1	Pre-op	15	1.319	0.106	0.519	<0.001*
	Post-op	15	0.799	0.056		
Group 2	Pre-op	15	1.265	0.099	0.311	<0.001*
	Post-op	15	0.954	0.08		
Group 3	Pre-op	15	1.27	0.104	0.42	<0.001*
	Post-op	15	0.849	0.062		
Group 4	Pre-op	15	1.296	0.115	0.295	<0.001*
	Post-op	15	1.001	0.091		

Comparison of mean Cervical dentin thickness (in mm) on Lingual Side b/w Pre-op and Post-op period in each study group using Student Paired t Test						
Groups	Time	N	Mean	SD	Mean Diff	P-Value
Group 1	Pre-op	15	1.319	0.106	0.519	<0.001*
	Post-op	15	0.799	0.056		
Group 2	Pre-op	15	1.265	0.099	0.311	<0.001*
	Post-op	15	0.954	0.08		
Group 3	Pre-op	15	1.27	0.104	0.42	<0.001*
	Post-op	15	0.849	0.062		
Group 4	Pre-op	15	1.296	0.115	0.295	<0.001*
	Post-op	15	1.001	0.091		

Comparison of mean Cervical dentin thickness (in mm) on Mesial Side b/w Pre-op and Post-op period in each study group using Student Paired t Test						
Groups	Time	N	Mean	SD	Mean Diff	P-Value
Group 1	Pre-op	15	1.319	0.106	0.519	<0.001*
	Post-op	15	0.799	0.056		
Group 2	Pre-op	15	1.265	0.099	0.311	<0.001*
	Post-op	15	0.954	0.08		
Group 3	Pre-op	15	1.27	0.104	0.42	<0.001*
	Post-op	15	0.849	0.062		
Group 4	Pre-op	15	1.296	0.115	0.295	<0.001*
	Post-op	15	1.001	0.091		

Comparison of mean Cervical dentin thickness (in mm) on Distal Side b/w Pre-op and Post-op period in each study group using Student Paired t Test						
Groups	Time	N	Mean	SD	Mean Diff	P-Value
Group 1	Pre-op	15	1.319	0.106	0.519	<0.001*
	Post-op	15	0.799	0.056		
Group 2	Pre-op	15	1.265	0.099	0.311	<0.001*
	Post-op	15	0.954	0.08		
Group 3	Pre-op	15	1.27	0.104	0.42	<0.001*
	Post-op	15	0.849	0.062		
Group 4	Pre-op	15	1.296	0.115	0.295	<0.001*
	Post-op	15	1.001	0.091		

\* Statistically Significant



**Graph 1**

#### 4. Discussion

Access cavity is the initial step in endodontic treatment and it is particularly important because it affects all subsequent procedures and finally the outcome. [9]The location and design of access cavity also has the effect on degree and distribution of instrumented root canal surface. Additionally, the location of access cavity affects the resistance to fracture and also determines the amount of preserved dentin in the

cingulum area in anterior teeth, which is important for the ferrule effect. [9]

In lower anterior teeth the “conventional” straight-line access is achieved through a cavity, made on palatal (or) lingual surface of the tooth. This design has many drawbacks such as undetected canals, inadequate chemo-mechanical and does not adhere to the main objectives of the access preparation. It can result in increased removal of

tooth structure from the central portion of the tooth which compromises the resistance of the tooth to fracture.<sup>[4]</sup>

The modification in access design is the “incisal approach.” It provides straight line and unimpeded access to the apical third of the root, reducing the risk of perforations and better preparation, especially in the apical third of the canal. It is beneficial for patients with limited mouth opening and preserves the mechanism of anterior guidance<sup>[5]</sup>.

More recently, the focus is shifting toward the preservation of tooth structure in a cervical portion of the tooth as this portion is considered to be most susceptible to fracture from occlusal forces. As the peri-cervical dentin extends 4 mm above and 4 mm below the CEJ, sections of 1 mm from this region were obtained and the peri-cervical dentin thickness was analysed for all the groups. The peri-cervical dentin thickness was calculated as the shortest distance from the canal outline to the closest adjacent root surface, which was measured in four surfaces, that is, facial, lingual, mesial and distal for all the groups in the three obtained C.B.C.T scans.<sup>[39]</sup>

In the present study freshly extracted permanent mandibular central incisors were used with a sample size of 60 teeth. Freshly extracted central incisors were used in this study as they have less chances of errors and straight line of access. Cone Beam Computed Tomography (C.B.C.T) was done before and after instrumentation of the samples.

Recently the Wave One Gold primary file has been introduced into the market. According to the manufacturer the file has reverse helix; semi active offset parallelogram shaped cross section with gold wire technology. There are four different Wave One Gold files are termed as small (yellow 20/07); primary (red 25/07); medium (green 35/06); large (black 45/05). Each file of Wave One Gold has fixed taper from D1 – D3 and progressively decreasing taper from D4 - D6, which serves to preserve more peri-cervical dentin. The primary file of Wave One Gold has a diameter of 0.85 mm – 1.0 mm at D9- D12. The primary file is the only file required to fully shape virtually in any canal.<sup>[38]</sup>

In this study Group IV Wave One Gold primary file with Incisal access cavity design has shown significant preservation of peri-cervical dentin in facial, lingual, mesial and distal when compared with other groups. [Table No.1; Table No.4; Graph 1; Colour plate 3& 6]. This can be justified as the Wave One Gold is single reciprocating file with decreasing taper from D<sub>3</sub> which preserves peri-cervical dentin. This result is in agreement with the study done by Vallabhaneni et al. in 2017 concluded that the Wave One Gold single reciprocation file respected original canal anatomy and preserves peri-cervical dentin better than Neoniti single continuous.<sup>[17]</sup>

This was followed by Group II Conventional access cavity preparation with Wave one gold file was significantly preserved more peri-cervical dentin when compared with group 1 and group 3 [Table No.1 ;Table No.4; Graph 1 ;Colour plate 3& 5]. However this result is contradictory with study done by Magne P et.al 2002; Surakanti et al.2018; stated that the presence of maintaining the cingulum and

lingual fossa has showed low stress concentration levels; improves the fracture resistance and longevity of tooth structure and the single file system. Wave one gold file proved larger amount of debris collection when compared with other single file system.<sup>[15]</sup>

In Group III Incisal access cavity preparation with Protaper file was showed lesser peri-cervical dentin [Table No. 1; Table No.4; Graph 1; Colour plate 3& 7]. This result is in similar with the study done by Varghese, et.al 2016 stated that the Incisal access cavity preparation with protaper rotary file in mandibular anterior teeth showed there is significant loss of peri-cervical dentin when compared with Conventional access cavity preparation.<sup>[9]</sup>

In Group I Conventional access cavity preparation with Protaper file was showed least peri-cervical dentin among all four groups. [Table No.1; Table No.4; Graph 1; Colour plate 3& 4]. This result is in similar with the study done by Hakan Arslan et al;<sup>[12]</sup> Carlos Menezes Aguiar et.al 2013<sup>[13]</sup> and Marlos Barbosa-Ribeiro et.al 2015,<sup>[14]</sup> which revealed that the root canal transportation showed more for Protaper universal rotary files and conserve less dentin thickness when evaluated with Cone beam computed tomography.

Multiple comparison of between four study groups showed that Group 4 Wave one gold primary file with Incisal access cavity preparation showed significantly higher mean peri-cervical dentin thickness as compared to Group 1 and Group 3 at P<0.001. This was followed by Group 2 showing significantly higher dentin thickness as compared to Group 1 and Group 3 at P<0.001 and P=0.001 respectively. However, no significant difference was found between Group 1 and Group 3 [P=0.26] and between Group 2 and Group 4 [0.30]. [Table No.2 & Graph 1]. Protaper rotary file preserve less peri-cervical dentin in coronal portion of tooth because of the usage of orifice opening file (S<sub>x</sub>) which has a D<sub>0</sub> diameter of 0.19 mm and a D<sub>14</sub> diameter approaching 1.20 mm increasingly larger percentage tapers with the cutting blades allowing to engage, cut and prepare a specific area of the canal. These results indicate that the file system is influencing more on peri-cervical dentin preservation than access cavity design. Usage of Protaper S<sub>x</sub> file removed more peri-cervical dentin.

Previous scientific reports Zinge et al 2017 showed that there was no significant difference found between rotary single-file systems and reciprocating single-file systems in their effect on peri-cervical dentin.<sup>[8]</sup> The other reports demonstrated that preparation of Incisal access cavity preparation with Wave one gold primary file application results in preservation of peri-cervical dentin thickness; provide centered canal preparations and also collect amount of dentinal debris. Additionally, Varghese, et.al 2016 found that preparation of Incisal access cavity preserved more peri-cervical dentin thickness.<sup>[9]</sup> This method is the only one proven clinically, is easy to adopt, and will likely be the first to gain wider acceptance.

Further studies on influence of different access preparation approaches on the quality of cleaning and shaping; obturation; post-operative restoration and fracture resistance before incorporating into our routine clinical practice.

## 5. Conclusion

Within the limitations of the present study it is concluded that the:-

- 1) Both access cavity design (Conventional and Incisal access cavity design) results in loss of tooth structure in peri-cervical region following excess as well instrumentation of root canal.
- 2) Between Conventional access cavity and Incisal access cavity preparation there is no significant loss of peri-cervical dentin.
- 3) Wave One Gold Primary file significantly preserved peri-cervical dentin compared to Protaper rotary file.
- 4) Incisal access cavity preparation with Wave One Gold Primary file resulted in preservation of peri-cervical dentin significantly.

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