ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1519

Comparative Evaluation of Microcrack Formation by K Files Using Mechanical Technique with Help of Reciprocating Contra-Angle Handpiece and Manual Technique: An Invitro Study

[1)] Dr. Shivangi Pujara
Department of Conservative Dentistry and Endodontics
Government Dental College and Hospital, Jamnagar
Jamnagar, India

[2)] Dr. Leena Jobanputra
Department of Conservative Dentistry and Endodontics
Government Dental College and Hospital, Jamnagar
Jamnagar, India

[3)] Dr. Pushpa Kumari
Department of Conservative Dentistry and Endodontics
Government Dental College and Hospital, Jamnagar
Jamnagar, India

[4)] Dr. Krupali Kalena
Department of Conservative Dentistry and Endodontics
Government Dental College and Hospital, Jamnagar
Jamnagar, India

[5)] Dr. Hardik Shah
Department of Conservative Dentistry and Endodontics
Government Dental College and Hospital, Jamnagar
Jamnagar, India

[6)] Dr. Harika Aroori
Department of Conservative Dentistry and Endodontics
Government Dental College and Hospital, Jamnagar
Jamnagar, India

[7)] Dr. Mital Prajapati
Department of Conservative Dentistry and Endodontics
Government Dental College and Hospital, Jamnagar
Jamnagar, India

[8)] Dr. Jigar Thakkar
Department of Oral and Maxillofacial
Pathology and Microbiology
Ahmedabad Dental College and Hospital

Abstract:-

➢ ***Introduction***

Effective root canal preparation is essential for successful treatment, focusing on thorough cleaning and shaping to prevent complications like vertical root fractures. Different tools, such as stainless steel and nickel-titanium files, offer advantages and drawbacks, impacting the risk of dentinal microcracks. This study examines the incidence of these cracks using both manual and reciprocating techniques with K files.

➢ ***Material and Method***

This study involved 150 mandibular premolars, divided into five groups to evaluate dentinal crack formation with different file systems. Groups included manual and mechanical instrumentation with stainless steel (S.S.) and nickel-titanium (NiTi) files, with one control group. After standard root canal preparation and irrigation, each root was sectioned and examined under a stereomicroscope to document crack formation. Data was analysed using Chi-square test, and Fisher's Exact test.

➢ ***Result***

There is no statistical significant difference among groups.

➢ ***Conclusion***

Maintaining root integrity in root canal treatment is vital, with similar crack formation seen in both manual and reciprocating techniques. Reciprocating handpieces offer a cost-effective, efficient option, beneficial for student training in modern endodontics.

Keywords:- *Root Canal Treatment, Cracks, Vertical Root Fracture, Reciprocation, Hand files.*

I. INTRODUCTION

Proper preparation of the root canal system is crucial for effective root canal treatment (RCT). Chemo-mechanical preparation helps eliminate microorganisms, pulp tissue, and debris, while widening the canal to allow for obturation materials. (1) Thorough cleaning and shaping are essential for a positive treatment outcome. (2) Nonetheless, errors such as perforations, canal deviations, ledge formation, and instrument fractures may arise during the procedure. (3)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1519

Cracks in the tooth, such as dentinal cracks, are a significant concern. These cracks may evolve into vertical root fractures (VRFs) under occlusal forces. (4) VRF is a common reason for tooth extraction after RCT. Although direct evidence linking dentinal defects like microcracks to VRFs is limited, dental professionals agree that prevention is key. (5) Studies have shown that dentinal microcracks can arise from the use of rotary and reciprocating instruments during root canal preparation. (6)

Endodontic hand K-files, introduced in 1915, are used for cleaning and shaping root canals. Standardized in 1974, these files are available in stainless steel (S.S.) and nickel-titanium (NiTi) materials. S.S. files are durable but rigid, which increases the risk of canal transportation and instrument fractures. NiTi files are more flexible, making them ideal for curved canals, though they are more prone to fracture and are expensive. (7,8)

Manual use of hand files can cause operator fatigue, leading to procedural errors. Reciprocating handpieces, introduced in 1928, simplify the process by using a back-and-forth motion, which reduces the risk of file fractures and decreases operator fatigue. Research shows that reciprocating handpieces lower pain, inflammation, and the likelihood of file anchorage or canal locking. (9,10) This study compares the formation of dentinal microcracks between S.S. and NiTi files, using conventional techniques and a reciprocating handpiece at different levels of the mandibular first premolar.

This study aimed to evaluate and compare the incidence of dentinal cracks following root canal preparation using stainless steel and NiTi K files, both manually and with a reciprocating handpiece, examined under a stereomicroscope.

II. MATERIALS AND METHODS

One hundred fifty (150) human permanent mandibular premolars (Figure 1), selected from the Department of Oral and Maxillofacial Surgery, were used in this study. Only single-rooted teeth indicated for orthodontic extraction were included. The samples were randomly divided into five groups, each assigned a different file system for root canal preparation to assess dentinal crack formation. Ethical clearance was obtained, under approval number of 61/02/2022.

Inclusion Criteria: Mandibular premolar teeth with one root, one canal, one apical foramen not larger than size # 15k file, Teeth with no root fractures or cracks, Teeth with no calcification, non-carious teeth, Teeth with almost straight root (root curvature < and closed apices. (According to Schneider method).

Exclusion Criteria: Teeth with root fractures, cracks, or open apices. Teeth with multiple roots, curved canals, calcified canals, Previous root canal treatment. Carious or previously restored teeth. Teeth with severe anatomic variations, Teeth with internal or external resorption.

Teeth were cleaned by an ultrasonic scaler and were disinfected with 0.5% NaOCl. The teeth were kept hydrated during experiments by storing them in distilled water.

- Group 1: No instrumentation (control)
- Group 2: Instrumentation with manual technique using S.S. K files.
- Group 3: Instrumentation with manual technique using NiTi K files.
- Group 4: Mechanical instrumentation with reciprocating contra-angle handpiece using S.S. K files.
- Group 5: Mechanical instrumentation with reciprocating contra-angle handpiece using NiTi files.

The crowns were sectioned with a 0.2 mm diamond disc and a low-speed handpiece under water irrigation, ensuring a root length of 17 mm for direct canal access. To determine the working length (WL), a #10 K file was inserted until visible at the apex, then retracted 1 mm. Each root was coated with 0.2–0.3 mm of aluminum foil below the CEJ and mounted in self-curing acrylic resin up to the CEJ. After setting, the foil was removed, and polyvinyl siloxane (PVS) was applied around the root to simulate the periodontal ligament, embedding the roots in acrylic blocks to mimic bone. Root canal instrumentation was completed before the PVS hardened to maintain its properties.

Teeth in group 1(n=30) were left uninstrumented as Control.

➢ *According to methodology there were four different groups.*

- Teeth in group 2 (n = 30) were instrumented with S.S. K files with watch winding motion to reach the working length and prepared using sequential filing in conventional manner.
- Teeth in group 3 (n = 30) were instrumented with NiTi K files with watch winding motion to reach the working length and prepared using sequential filing in conventional manner.
- Teeth in group 4 (n = 30) were instrumented with a reciprocating contra-angle handpiece (NSK 10:1) using S.S. K-files.
- Teeth in group 5 (n = 30) were instrumented with a reciprocating contra-angle handpiece (NSK 10:1) using NiTi K files.

In all groups, a #10 K-file was used for initial filing and to maintain canal patency. Canals were prepared to apical size #25, then up to size #40 using a step-back technique with 1-mm increments. Between instruments, canals were irrigated with 1 ml of 3% NaOCl, followed by a final rinse with 5 ml of 3% NaOCl, saline, and 17% EDTA using a 30-G needle. After chemo-mechanical preparation, roots were removed from acrylic molds and silicone, then stored in distilled water to maintain hydration. Roots were horizontally sectioned at 3, 6, and 9 mm from the apex with a low-speed handpiece and a 0.2 mm diamond disc under water cooling. Each section was examined under a stereomicroscope at 40x magnification, with digital images

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1519

captured to record the frequency of cracks. Roots with cracks extending from the canal wall to the root surface in any section were classified as cracked, and all images were scored by the operator.

Table 1: Score

SCORE	DEFECTS
0	No Defects
1	Cracks

Table:2 No Defect and Cracks

No defect (Figure 2)	No cracks or lines present on either the internal or external surface of the root dentin.
External Crack (Figure 3)	A crack line originating from the outer surface of the root dentin that does not extend to the canal wall.
Incomplete internal crack (Figure 4)	A crack line that begins at the internal surface (canal wall) and progresses into the dentin without reaching the external surface.
Complete Internal crack	A crack line that extends from the internal surface of the canal wall to the outer surface of the root.

Data was analysed using SPSS version 20.0. The following statistical tests were done:

(1) Chi-square test
(2) Fisher's Exact test

NULL HYPOTHESIS: H0= There is no difference in dentinal crack formation among the groups (Manual Hand File S.S. and NiTi, Mechanically Hand files S.S. and NiTi) and coronal, middle, and apical third regions. Level of Significance $P \leq 0.05$

III. RESULT

Table 3: Types of Dentinal Cracks in All the Groups at various level

Portion	Score	Control	Manual S.S.	Manual NiTi	Mechanical S.S.	Mechanical NiTi	P value Fisher's exact test
3mm (Apical)	No Defect	29(96.6)	26(86.6)	29(96.6)	28(93.3)	27(90)	0.30**
	External Crack	1(3.3)	3(10)	1(3.3)	1(3.3)	2(6.6)	
	Incomplete Internal Crack	0(0)	1(3.3)	0(0)	1(3.3)	1(3.3)	
	Complete Internal Crack	0(0)	0(0)	0(0)	0(0)	0(0)	
6mm (Middle)	No Defect	28(93.3)	27(90)	26(86.6)	26(86.6)	27(90)	0.97**
	External Crack	2(6.6)	2(6.6)	3(10)	3(10)	3(10)	
	Incomplete Internal Crack	0(0)	1(3.3)	1(3.3)	1(3.3)	0(0)	
	Complete Internal Crack	0(0)	0(0)	0(0)	0(0)	0(0)	
9mm (Coronal)	No Defect	26(86.6)	27(90)	27(90)	29(96.6)	28(93.3)	0.91**
	External Crack	3(10)	3(10)	3(10)	1(3.3)	2(6.6)	
	Incomplete Internal Crack	0(0)	0(0)	0(0)	0(0)	0(0)	
	Complete Internal Crack	0(0)	0(0)	0(0)	0(0)	0(0)	

Level of Significance $P \leq 0.05$, * Significant, ** Non-Significant

IV. DISCUSSION

Optimal root canal preparation is essential in endodontic therapy to preserve the canal's natural anatomy and ensure thorough cleaning of the root canal system. (11) Despite advancements in mechanical techniques like rotary and reciprocating systems, challenges such as vertical root fractures (VRF) remain, threatening treatment outcomes and tooth preservation. (12) A key concern is the formation of microcracks in the root structure, which, though initially imperceptible, can compromise tooth integrity and lead to fractures. Understanding the mechanisms behind microcrack formation in various root canal preparation systems is

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1519

crucial for improving treatment and reducing iatrogenic damage. (13)

The evolution of endodontic techniques reflects the dental community's pursuit of efficiency and patient comfort. Continuous rotary and reciprocating systems have gained popularity, offering benefits like reduced operative time and operator fatigue. However, manual instrumentation remains essential for initial canal negotiation, establishing glide paths, determining working lengths, and verifying patency. (14)

Despite the popularity of mechanized systems, factors like cost and accessibility affect their adoption, especially in academic settings. Reciprocating handpieces with conventional files offer a cost-effective alternative to continuous rotary systems. (15)

This study aimed to compare microcrack formation during root canal preparation using the NSK TEP ER 10 Handpiece and manual techniques. The use of hand files is supported by studies such as those by Yoldas et al. and Hin et al., which highlight the advantages of hand instrumentation. Hand files, with their less aggressive movements and lower taper (0.02), exert less stress on the dentin compared to rotary Ni-Ti instruments, which have greater taper configurations. (16,17)

Studies have shown that dentin removal during root canal instrumentation is influenced by factors such as instrument shape, speed, torque, and penetration depth. Rotary instruments with greater taper profiles remove more dentin than hand files with a standard 0.02 taper. Additionally, rotary Ni-Ti files often require more rotations to complete preparation, leading to increased mechanical stress on dentinal integrity. (18)

The more aggressive action of rotary instruments may contribute to dentinal defects like microcracks. This study's focus on hand files aims to minimize iatrogenic damage by reducing dentin removal and mechanical stress. By emphasizing hand instrumentation, the goal is to evaluate microcrack formation under controlled conditions, highlighting the impact of different techniques on dentinal integrity and treatment outcomes. (19)

The choice of the NSK TEP ER 10 reciprocating handpiece, with its 60-degree reciprocating motion, was intentional. Unlike the M4 handpiece (30-degree) and Micromega's girometric handpiece (90-degree), no study has assessed crack formation using a hand file mounted on a reciprocating handpiece.

Mandibular premolars were selected for their wide, straight canals, which provide consistent access and instrumentation, making them ideal for evaluating the reciprocating technique. These teeth are common in clinical practice, and studying microcrack formation in them has practical implications for endodontic procedures.

To standardize the study, decoronation was performed to eliminate cervical curvature, reducing variability and ensuring more controlled conditions when comparing mechanical reciprocating and conventional techniques.

Disinfecting teeth with 0.1% Hypochlorite and storing them in distilled water prevents dehydration, which can cause stress and dentinal cracks. Dehydration leads to uneven shrinkage, increasing internal stresses that may cause cracking. (20)

Self-cure acrylic resin and polyvinylsiloxane impression material were used to replicate the jawbone and periodontal ligament, simulating stress absorption during procedures. Bahrami et al. found no significant difference in microcrack characteristics between control and experimental groups in cadaver teeth. (21)

A 3% NaOCl solution was chosen over 5.25% to prevent reductions in dentin's elastic modulus and flexural strength, ensuring effective disinfection with minimal impact. Samples were sectioned with a water-cooled diamond disc, a standard method for assessing dentinal defects. Studies consistently show control sections remain crack-free, highlighting the role of instrumentation techniques in dentinal defects and aiding in examining the effects of these techniques on root structure. (22)

The study found preexisting microcracks in the control group, suggesting natural microcracks in teeth, aligning with Cavalcante's micro-CT findings in mandibular incisors. These cracks likely result from daily mechanical stresses (chewing, biting), environmental factors (temperature changes, diet), and natural variations in enamel density and mineralization. (23)

No complete internal cracks were observed in any group, which could otherwise increase the risk of vertical root fractures. Incomplete internal cracks appeared only in the apical and middle thirds, not in the coronal segment, aligning with findings by Nishad and Shivamurthy, and Chole. These microcracks may result from repeated instrumentation stresses and the fragile dentin in the apical third, which is susceptible to direct mechanical impact from instrument tips. (24,25)

Comparing manual and mechanical Stainless Steel (S.S.) and NiTi groups revealed no significant differences in crack formation, indicating that instrumentation method and material type do not affect crack occurrence. Although the use of hand files on reciprocating handpieces is not yet widespread, these tools offer similar performance to conventional techniques in terms of microcrack formation. Additionally, reciprocating handpieces address conventional method drawbacks like time, fatigue, and effort, presenting an efficient alternative. (26)

A stereomicroscope was selected over micro-CT to evaluate dentinal cracks, as it provides higher resolution and clarity, allowing for a more precise examination. While micro-CT offers many slices, it may miss some microcracks,

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1519

making the stereomicroscope a more reliable choice for accurate crack identification and enhancing the study's validity. (27)

Study limitations include the use of PVS for PDL simulation and acrylic resin for bone, which do not fully replicate oral cavity conditions, indicating a need for in-vivo studies. Additionally, stereomicroscopic crack evaluation is a destructive method, potentially contributing to crack formation during sectioning.

V. CONCLUSION

Maintaining root integrity during root canal treatment is essential, as dentinal damage can result from the teeth's physical properties, instrumentation, and techniques used. This study found comparable crack formation between conventional techniques and hand files on reciprocating handpieces, indicating that method choice may not significantly affect crack development. Adopting reciprocating handpieces presents an efficient, cost-effective alternative, particularly valuable in academic settings. This approach reduces dependence on manual techniques, offering students exposure to modern technologies, thus enhancing their training experience.

REFERENCES

[1]. Schilder H. Cleaning and shaping the root canal. Dent Clin North Am. 1974;18(2):269-96.
[2]. Peters OA. Current challenges and concepts in the preparation of root canal systems: A review. J Endod. 2004;30:559– 67.
[3]. Kruzic, J., Nalla, R., Kinney, J., & Ritchie, R. (2005). Mechanistic aspects of in vitro fatigue-crack growth in dentin. Biomaterials, 26(10), 1195-1204.
[4]. Burklein S, Tsotsis P, Schafer E. Incidence of dentinal defects after root canal preparation: Reciprocating versus Rotary instrumentation. J Endod 2013;39(4):501–4.
[5]. Wilcox LR, Roskelley C, Sutton T. The relationship of root canal enlargement to finger spreader induced vertical root fracture. J Endod 1997;23(8):533–4
[6]. Versiani, M. A., Souza, E., & De-Deus, G. (2015). Critical appraisal of studies on dentinal radicular microcracks in endodontics: Methodological issues, contemporary concepts, and future perspectives. Endodontic Topics, 33(1), 87-156.
[7]. Alrahabi, Mothanna. (2015). Comparative study of root-canal shaping with stainless steel and rotary NiTi files performed by preclinical dental students. Technology and health care: official journal of the European Society for Engineering and Medicine.
[8]. Lloyd A, Jaunberzins A, Dhopatkar A, Bryant S, Dummer P. Shaping ability of the M4 handpiece and Safety Hedstrom Files in simulated root canals. Int Endod J. 1997;30(1):16-24.
[9]. Pujara SM, Shah HB, Jobanputra LH. Comparative Evaluation of the Cyclic Fatigue Resistance of WaveOne Gold in Reciprocation, ProGlider in Rotary Motion, and Manual Files in a Reciprocating Handpiece Within Simulated Curved Canals: An In Vitro Study. Cureus. 2024 Aug 24;16(8):e67704. doi: 10.7759/cureus.67704. PMID: 39318919; PMCID: PMC11420601.
[10]. Labbaf H, Shakeri L, Orduie R, Bastami F. Apical Extrusion of Debris after Canal Preparation with Hand-Files Used Manually or Installed on Reciprocating Air-Driven Handpiece in Straight and Curved Canals. Iran Endod J. 2015;10(3):165.
[11]. Kandaswamy D, Venkateshbabu N. Root canal irrigants. Journal of Conservative Dentistry and Endodontics. 2010 Oct 1;13(4):256-64.
[12]. Patel S, Bhuva B, Bose R. Present status and future directions: vertical root fractures in root filled teeth. International Endodontic Journal. 2022 May;55:804-26.
[13]. Cameron CE. Cracked-tooth syndrome. The Journal of the American Dental Association. 1964 Mar 1;68(3):405-11.
[14]. Mohan BG, Shivakumar D, Penumaka SL, Althaf S, Garg G, Subramani SK, GOWDA BG, Disha S, laxmi Penumaka S. To Evaluate Different Endodontic Instrumentation Systems Regarding Post-Operative Pain After Endodontic Therapy: A Clinical Study. Cureus. 2024 Mar 19;16(3)
[15]. Plotino G, Nagendrababu V, Bukiet F, Grande NM, Veettil SK, De-Deus G, Ahmed HM. Influence of negotiation, glide path, and preflaring procedures on root canal shaping—terminology, basic concepts, and a systematic review. Journal of endodontics. 2020 Jun 1;46(6):707-29.
[16]. Yoldas O, Yilmaz S, Atakan G, Kuden C, Kasan Z. Dentinal microcrack formation during root canal preparations by different NiTi rotary instruments and the self-adjusting file. Journal of endodontics. 2012 Feb 1;38(2):232-5.
[17]. Hin ES, Wu MK, Wesselink PR, Shemesh H. Effects of self-adjusting file, Mtwo, and ProTaper on the root canal wall. J. Endod. 2013 Feb 1;39(2):262-4.
[18]. Garg S, Mahajan P, Thaman D, Monga P. Comparison of dentinal damage induced by different nickel-titanium rotary instruments during canal preparation: An in vitro study. J. Conserv Dent. 2015 Jul;18(4):302-5.
[19]. Crespo S, Cortés O, García C, Pérez L. Comparison between rotary and manual instrumentation in primary teeth. Journal of Clinical Pediatric Dentistry. 2008 Jul 1;32(4):295-8.
[20]. Winter W, Karl M. Dehydration-induced shrinkage of dentin as a potential cause of vertical root fractures. Journal of the mechanical behavior of biomedical materials. 2012 Oct 1;14:1-6.
[21]. Rathi A, Chowdhry P, Kaushik M, Reddy P, Mehra N. Effect of different periodontal ligament simulating materials on the incidence of dentinal cracks during root canal preparation. Journal of dental research, dental clinics, dental prospects. 2018;12(3):196.
[22]. Xu H, Ye Z, Zhang A, Lin F, Fu J, Fok AS. Effects of concentration of sodium hypochlorite as an endodontic irrigant on the mechanical and structural properties of

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1519

root dentine: A laboratory study. International endodontic journal. 2022 Oct;55(10):1091-102.
[23]. Kesim B, Sagsen B, Aslan T. Evaluation of dentinal defects during root canal preparation using thermomechanically processed nickel-titanium files. European journal of dentistry. 2017 Apr;11(02):157-61.
[24]. Nishad SV, Shivamurthy GB. Comparative analysis of apical root crack propagation after root canal preparation at different instrumentation lengths using ProTaper universal, ProTaper next and ProTaper gold rotary files: an in vitro study. Contemp. Clin. Dent. 2018 Jun;9(Suppl 1):S34-S38.
[25]. Chole D, Kamble S, Bakle S, Gandhi N, Hatte N, Bawa P. Effects of 3 Single-File System (Protaper Universal, Protaper Next, Protaper Gold) on crack formation in dentin after root canal preparation-An in vitro study. IOSR-JDMS. 2019;18:47-50.
[26]. Sonntag D, Delschen S, Stachniss V. Root-canal shaping with manual and rotary Ni-Ti files performed by students. International endodontic journal. 2003 Nov;36(11):715-23
[27]. Soujanya E, Verma N, Kaushik M, Nagamaheshwari X, Mehra N, Prasad LK. Effect of three different rotary file systems on dentinal crack formation–A stereomicroscopic analysis. Endod. 2020 Oct 1;32(4):220-24.

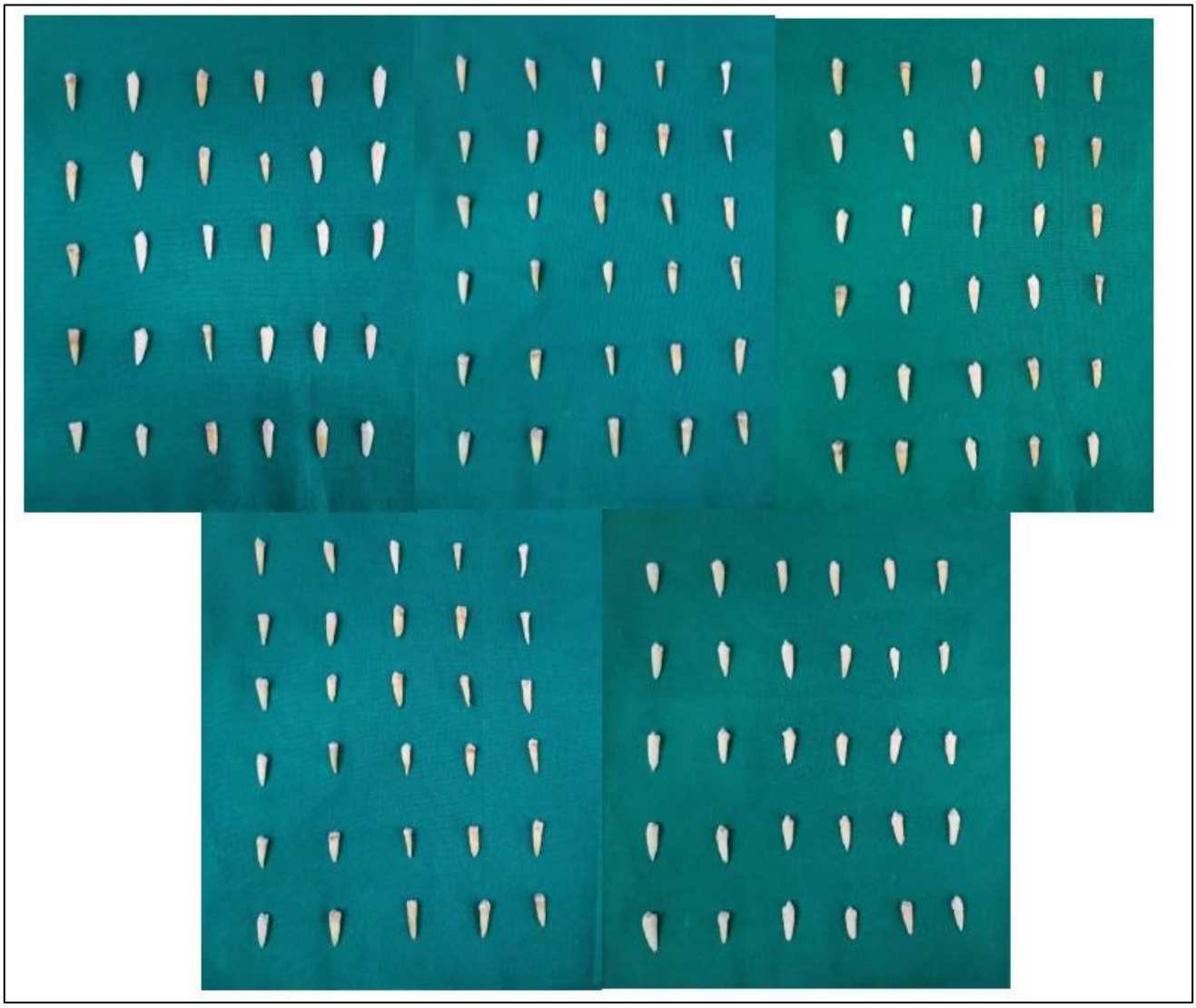

Fig 1 : 150 Mandibular Premolar

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1519

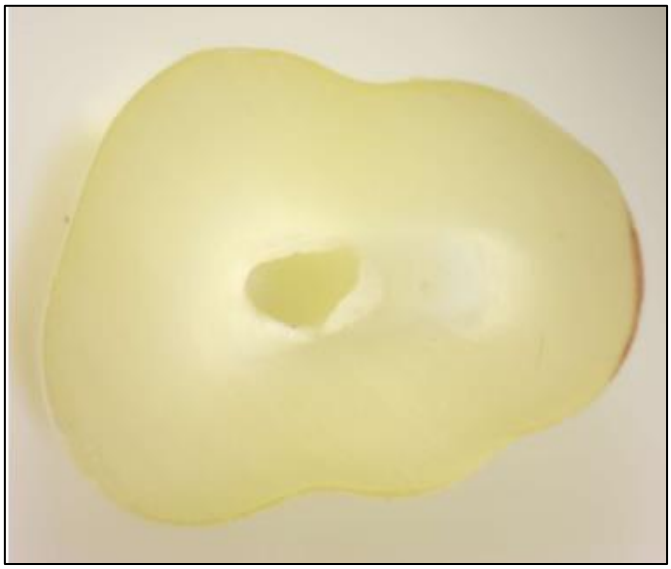

Fig 2: No Defect

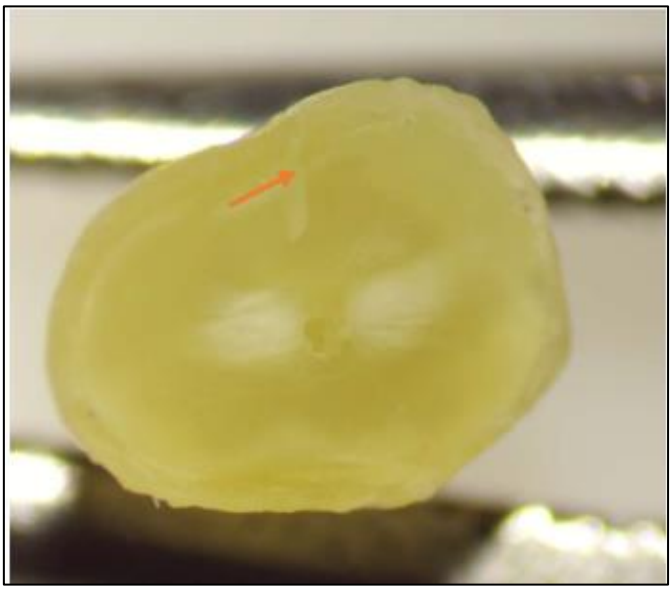

Fig 3: External Crack

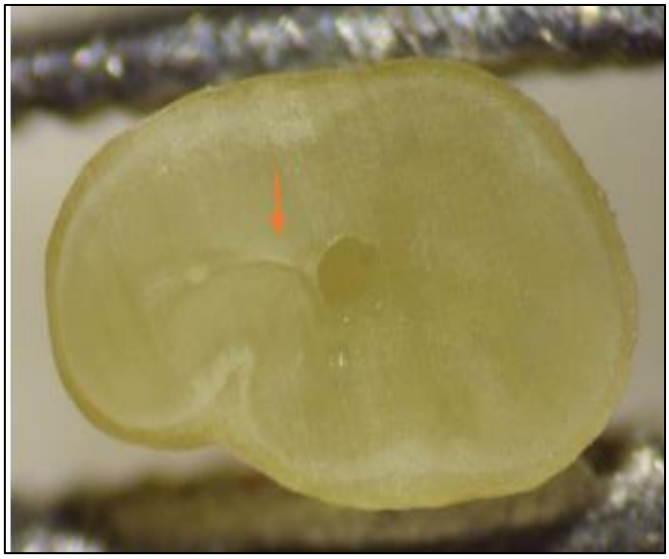

Fig 4: Incomplete Internal Crack