# Clinical assessment of identification of symptomatic tooth by the patients and the clinicians in various endodontic emergencies: A cross-sectional hospital-based study

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## Abstract

**Introduction:** Pain of endodontic origin is the major cause to seek emergency dental services. Identification of the offending tooth is very crucial for its emergency management and to maintain a healthy Doctor-patient relationship.

**Aim:** This study was conducted to evaluate the frequency of identification of the painful tooth by the patient and the clinician in various Endodontic Emergencies (EE).

**Methodology:** 352 patients with EE who had given voluntary consent for the study were evaluated in this study. Identification of offending painful tooth was done by the patient and it was also identified and diagnosed by Endodontists using a standard clinical protocol and Visual Numeric Analogue Scale (VNAS). The frequency of identification of painful tooth by patients and clinicians was assessed and compared.

**Results:** The results of this study showed that patients were less accurate than the clinicians in identification of painful tooth in EE especially in Symptomatic Irreversible Pulpitis (SIP).

**Conclusion:** Clinician's knowledge, judgement and experience helps to locate the offending tooth precisely in EE. The spread of the infection to the periradicular area significantly increases the probability of identification of the painful tooth by the patients and clinicians.

**Keywords:** Dentist, Doctor-patient relationship, Endodontic Emergencies, Painful tooth.

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## Introduction

In day to day dental practice, the pain of endodontic origin is the common cause which often requires the patient to visit the dentist on emergency basis.[1] International Association for the Study of Pain defines pain as, "Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage."[2] Endodontic Emergency (EE) may be observed as an acute pulpal pain, acute apical abscess, phoenix abscess or the trauma causing the pulpal injury.

When the patient visits the dentist in emergency, the quick and prompt diagnosis is vital and the treatment should be directed to relieve the painful episode. In that visit, the patient narrates the history of spontaneous or continuous, throbbing pain or swelling or trauma associated with a particular tooth or teeth. Often, the patient may not always be able to locate the involved tooth which causes severe odontalgia. Thus, the patient may demand treatment of wrong tooth by their mis-judgement. Different EE have presented clinically such as; Symptomatic Reversible Pulpitis (SRP), Symptomatic Irreversible Pulpitis (SIP), Symptomatic Acute Apical Periodontitis (SAAP) or Acute Apical Abscess (AAA).[3]

In a dental emergency, the identification of a painful tooth is also important to gain the patient's confidence in the dentist. Improper diagnosis may not cause the relief, rather it would degenerate the patient's trust and confidence in the treating dentist. The fundamental of this study was based on

whether the dentist should blindly trust patient in identification of painful tooth in EE or to carry out the diagnosis using their clinical knowledge, experience and clinical protocol. Thus, this study was conducted to evaluate, whether the patients reported with the EE could correctly identify the offending tooth as per the clinician's diagnosis and their pain severity was measured using Verbal Numerical Rating Scale (VNRS).[4]

## Methodology

For this purpose, a pilot study was carried out including 30 patients aged between 21-60 years. Patients were selected randomly, who were reported with EE in the Emergency unit of Department of Conservative Dentistry and Endodontics of the Government Dental College and Hospital, Mumbai; from the Out-Patient Department section (OPD) of the hospital. Selected patients were diagnosed by two experienced Endodontists based on the case history questionnaire, clinical evaluation and the radiographic examination. Identification of the painful tooth with its clinical diagnosis was established by both the clinicians separately for all the patients. When there was a disagreement of opinion, the inter-operator bias was eliminated by arriving at the final diagnosis through discussion by both the clinicians. In this pilot study, 17 (56.66%) patients identified the painful tooth correctly whereas; the clinicians identify the correct tooth in 29 (96.66%) patients.

In the present study 4000 adult patients, aged between 21 to 60 years (mean age 35.7 years); referred to the Department of Conservative Dentistry and Endodontics from a period of 01/06/2016 to 30/06/2018 (24 months) were screened. Among the screened patients, 400 patients irrespective of their gender exhibited EE were randomly selected. Out of 400 patients, 352 patients; who were willing to participate voluntarily in the study were evaluated. They were divided into four groups according to the age as 21-30, 31-40, 41-50 and 51-60 years.

### Inclusion criteria

1) Any male or female with the age between 21 to 60 years.
2) The patient diagnosed with EE.
3) The patient who gave the consent voluntarily for the study.

### Exclusion criteria

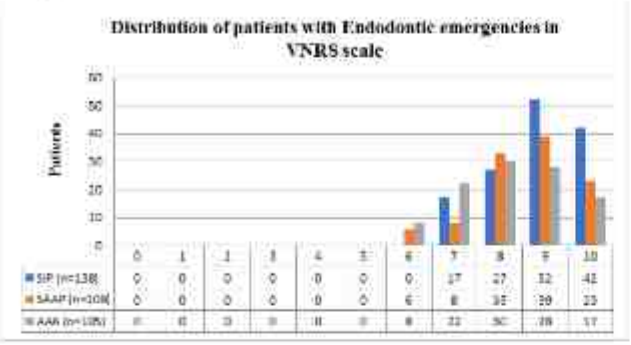
1) Patients having pain of non-endodontic origin.
2) All third molar teeth with EE.
3) Patients diagnosed with symptomatic reversible pulpitis, phoenix abscess and endodontic failure cases.
4) Patients on analgesic or antibiotic medications since a week.

The aim of the study was to assess whether the patients could precisely identify the troublesome tooth during their first endodontic emergency visit and compared it with the identification done by a team of two clinicians i.e. Endodontists. Diagnosis for each patient such as Symptomatic Irreversible Pulpitis (SIP), Symptomatic Acute Apical Periodontitis (SAAP) or Acute Alveolar Abscess (AAA) was done after thorough case history, clinical and radiographic examinations. All patients were scheduled immediately for EE management after the diagnosis irrespective of their participation in the study. The severity of pain was measured from 0 to 10 using VNRS Scale rating as 0-No pain to 10-Worst pain imaginable (Table I & Graph 1).[4] The correct frequency of identifying the painful tooth by the patient using their tongue, finger or

**Table I** : Distribution of patients with Endodontic emergencies with VNRS scale

| VNRS Scale | SIP (n=138) | SAAP (n=109) | AAA (n=105) |
|---|---|---|---|
| 0 (No pain) | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 |
| 5 (Moderate pain) | 0 | 0 | 0 |
| 6 | 0 | 6 | 8 |
| 7 | 17 | 8 | 22 |
| 8 | 27 | 33 | 30 |
| 9 | 52 | 39 | 28 |
| 10 (Extreme pain) | 42 | 23 | 17 |

**Graph I:** Distribution of patients with Endodontic emergencies in VNRS scale




the expression with the operator's diagnosis of the EE condition was noted and compared.

For the present study, a hypothesis was made, that the patients with symptomatic EE could identify the painful tooth more accurately when the disease advances from dental pulp to the periradicular tissues. Data obtained was compiled on MS Office Excel Sheet (v 2010) and was subject to statistical analysis using Statistical package for social sciences (SPSS v 21.0, IBM). Descriptive statistics like, disease-wise and gender-wise distribution was depicted. Comparison of frequencies of the patients to identify the correct painful tooth and pain severity and affecting teeth was done using Chi-square test. For all the statistical tests, $p<0.05$ was considered to be statistically significant.

## Results

Out of 352 selected patients with EE, 203 (57.7%) were males and 149 (42.3%) were females. Out of evaluated EE, 138 (39.2%), 109 (30.9%) and 105 (29.9%) patients were diagnosed as SIP, SAAP and AAA respectively. Results showed that the clinicians were more accurate in painful tooth identification than the patients. It was also observed that in SAAP or AAA when the disease progressed apically, the patients and the clinicians could identify the affected tooth more significantly than patients diagnosed with SIP (**Table II, III & Graph II, III**). It was also observed that the maxillary and mandibular molars were the most commonly affected teeth in EE (**Table IV**). Similarly, patients were more precise in the identification of painful teeth of the maxillary region than the mandibular molars.

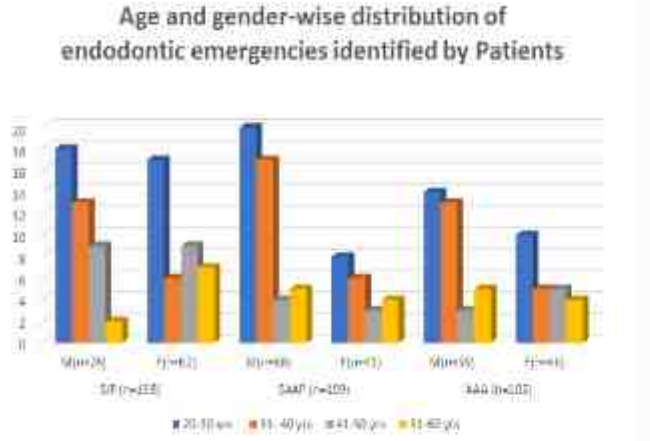
**Table II :** Age and gender-wise distribution of Endodontic emergencies identified by patients

| Age groups (n=352) | | SIP (n=138) | | SAAP (n=109) | | AAA (n=105) | |
|---|---|---|---|---|---|---|---|
| M (n=203) | F (n=149) | M(n=76) | F(n=62) | M(n=68) | F(n=41) | M(n=59) | F(n=46) |
| **20-30 yrs** | | 18/30 (60%) | 17/24 (70.8%) | 20/22 (90.9%) | 8/14 (57.1%) | 14/26 (53.8%) | 10/18 (55.5%) |
| **31- 40 yrs** | | 13/22 (59.0%) | 6/12 (50%) | 17/27 (62.9%) | 6/12 (50%) | 13/21 (61.9%) | 5/10 (50%) |
| **41-50 yrs** | | 9/18 (50%) | 9/15 (60%) | 4/8 (50%) | 3/8 (37.5%) | 3/7 (42.8%) | 5/9 (55.5%) |
| **51-60 yrs** | | 2/6 (33.3%) | 7/11 (63.6%) | 5/11 (45.4%) | 4/7 (57.1%) | 5/5 (100%) | 4/9 (44.4%) |

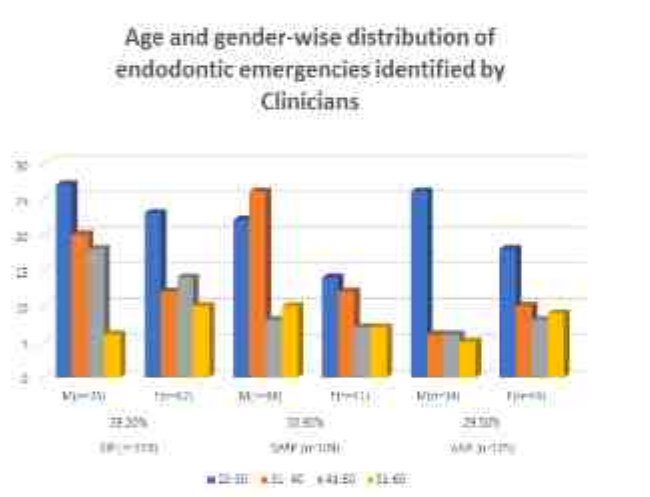
**Table III :** Age and gender-wise distribution of Endodontic emergencies identified by Clinicians

| Age groups (n=352) | | SIP (n=138) 39.2% | | SAAP (n=109) 30.9% | | AAA (n=105) 29.5% | |
|---|---|---|---|---|---|---|---|
| M (n=203) | F (n=149) | M(n=76) | F(n=62) | M(n=68) | F(n=41) | M(n=59) | F(n=46) |
| **20-30 yrs (n=134)** | | 27/30 (90%) | 23/24 (95.8%) | 22/22 (100%) | 14/14 (100%) | 26/26 (100%) | 18/18 (100%) |
| **31- 40 yrs (n= 104)** | | 20/22 (90%) | 12/12 (100%) | 26/27 (96.2%) | 12/12 (100%) | 21/21 (100%) | 10/10 (100%) |
| **41-50 yrs (n= 65)** | | 18/18 (100%) | 14/15 (93.33%) | 8/8 (100%) | 7/8 (87.5%) | 6/7 (85.7) | 8/9 (88.8%) |
| **51-60 yrs (n= 49)** | | 6/6 (100%) | 10/11 (90.9%) | 10/11 (90.9%) | 7/7 (100%) | 5/5 (100%) | 9/9 (100%) |

**Graph II** : Age and gender-wise distribution of endodontic emergencies identified by Patients




**Graph III** : Age and gender-wise distribution of endodontic emergencies identified by Clinicians




## Discussion

EE is an unpleasant and unexpected event in which a patient with odontalgia may visit the dental office at any time. In underdeveloped or developing countries due to inadequate health awareness regarding general as well as the oral health; people may visit the dentist usually when the pain is severe or when their routine functional life is disturbed. In a developing country like India; the oral health awareness has been increased drastically in urban sectors, leading to an increased number of patients visiting the dentist regularly. Some of the factors are still restraining the exposure of oral health services to the common masses including lack of education, poor economy, lack of time and the self oral health care negligence etc.

In the management of any EE, knowledge of such emergency and its diagnosis has a vital role. Academic emphasis on management of EE like imparting the knowledge, live doctor-patient communication, demonstration of various clinical examination, tests and investigations help to improve the patient management skills among the budding clinicians. Thus, it is recommended that before arriving at a diagnosis and initiating any endodontic treatment the patient's chief complaint must be reproduced. It is crucial, particularly when the patient may not be able to point out the offending tooth and may misguide the clinician. Thus, for successful endodontic practice standard clinical protocol has been adopted for diagnosis and treatment plan which includes; taking the detail case history, history of medications, thorough clinical examination, carrying out necessary clinical tests and the radiographic investigation of

**Table IV** : Quadrant-wise distribution of Endodontic emergencies identified by Clinicians

| Age groups 352 | Maxillary right side | | | | | | | Maxillary left side | | | | | | | Mandibular left side | | | | | | | Mandibular right side | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tooth no. | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
| 20-30 yrs | 6 | 4 | 3 | 3 | 3 | 6 | 6 | 6 | 4 | 3 | 4 | 5 | 7 | 6 | 4 | 3 | 4 | 5 | 5 | 8 | 7 | 3 | 3 | 3 | 5 | 6 | 7 | 5 |
| 31- 40 yrs | 3 | 3 | 4 | 4 | 3 | 5 | 5 | 3 | 5 | 2 | 3 | 2 | 5 | 6 | 5 | 2 | 1 | 2 | 4 | 6 | 4 | 3 | 4 | 3 | 5 | 6 | 6 | 5 |
| 41-50 yrs | 1 | 2 | 2 | 1 | 1 | 2 | 5 | 5 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 4 | 3 | 2 | 2 | 1 | 3 | 1 | 4 | 3 |
| 51-60 yrs | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 2 |

the patient.[6] Usually, diagnosis depends on the clinical symptoms and intraoral radiographs but Cone Beam Computed Tomography (CBCT) is superior to conventional radiographs in diagnosing the periapical pathosis when there are no signs or symptoms to conclude the correct diagnosis.[8] Similarly, the patients on analgesic or antibiotic medications were excluded from this study as these drugs may mask the symptoms and lead to incorrect diagnosis.[7]

In clinical point of view, the diagnosis of EE essential not only to manage the painful episode but also; to prevent the systemic spread of the infection leading to life-threatening conditions like space infection or Ludwig's angina.[8,9] A rare complication was reported in a case where patient died because of the cavernous sinus thrombophlebitis following the root canal treatment where; the most the suspected route for the spread of the infection was from the tooth to the maxillary sinus, the eye and the brain.[10] Thus, dilemma or wrong identification of affected tooth by the patient or the clinician may lead to wrong diagnosis, treatment or life threatening complications. It may also result in the persistence of the pain which leads to loss of the trust in the operating dentist.

Sometimes in clinical practice, diagnosing the SAAP and the SIP is confusing because of similar clinical symptoms whereas; the diagnosis of AAA is much simpler due to the obvious or visible swelling associated with the carious tooth. SIP is usually presented as severe, sharp-shooting, continuous pain associated with irreversible inflammation of the pulp whereas; SAAP indicates the spread of infection to periradicular tissue and the tooth becomes tender to percussion. Relief from the pain after a cold application in SIP is the key feature to distinguish between SIP and SAP. Also, SAP diagnosed teeth may present with a history of severe pain to cold stimuli for less than a week and the probability of diagnosed SAP was 72 %.[11] In a study, the clinical diagnosis of healthy pulp and reversible pulpitis were coincident with the histologic finding in 96.6% teeth whereas; the clinical and histologic finding of irreversible pulpitis coincided in only 84.4% cases.[12]

In the complicated cases when such infection remained undiagnosed and untreated, it leads to the formation of the periapical lesion and may cause systemic infection.[9] It is well documented that in the majority of the painful conditions of teeth involving EE; could be diagnosed using electric and cold stimuli. Painful tooth identification in the maxillary or mandibular arch may also vary and it may depend on the type of teeth involved. Results of our study indicated that patients may not correctly identify the offending tooth diagnosed with SIP but as the infection advanced to the periradicular area, the identification of painful tooth becomes more specific as in cases of SAAP or AAA.

The diagnosis is important in various EE; as the management also varies from case to case.[8,13] Removal of a major portion or complete inflamed pulp tissue relieves the patient's pain in SIP whereas; thorough cleaning-shaping with or without occlusal grinding is recommended to relieve the pain in patients with SAAP.[14] The patient with AAA, usually requires drainage either through root canal or through fluctuant and dependent soft tissues. The complication may arise when the spread of infection occurs from the infected tooth to the other vital structures or facial spaces present in the proximity. SAAP or AAA may also endanger the life of the patient if not treated appropriately and timely due to bacteraemia, septicaemia and the systemic involvement.[15]

In a busy schedule of modern dental practice; when unexpected EE case has reported to the dentist, where there may be limited time permitted for the treatment, the procedures for relieving the pain in SAAP and SIP may also vary. In a short time, the EE management for single-rooted and multi-rooted teeth may also differ. In SIP or SAAP of the single-rooted tooth, removal of the complete pulp tissue is advised whereas; in multi-rooted tooth with SIP, removal of coronal inflamed pulp i.e. pulpotomy may relieve the pain. In case of SAAP when the time does not permit the pulpectomy; the removal of pulp tissue from the largest root canal is generally recommended.

Treating the EE is a challenging task as the patient's sensibility is altered due to severe pain and difficulty in achieving anaesthesia especially in 'Hot Tooth' as in SIP or SAAP. Teeth with AAA usually do not require anaesthesia to get access to the pulp chamber. But, sometimes one or the other canal may exhibit partially vital pulp tissue which may need the pulpal anaesthesia for complete pulp extirpation and the debridement.

Diagnosis of EE is a critical issue as it requires skill and knowledge to identify the offending tooth and to gain the patient's confidence. The dentist-patient relationship relies on the trust in doctor's knowledge, skills, communication as well as correct diagnosis and treatment rendered by the doctor, especially critical situations like EE. In our study, the

gender and age of the patients have not shown any significant difference in the identification of painful tooth when compared to different EE. Diagnosis made by the clinicians was also consistent and there exists no statistically significant difference. Among all emergencies, the large number of patients diagnosed with AAA could be able to identify the painful tooth, followed by SAAP and SIP conditions. Identification of the offending tooth by clinicians and tooth identified by patients may not be the same in more than half of the cases of SIP; but as the diseases progress, identification of painful tooth becomes accurate for the patient especially in AAA cases and was similar to the observations of the clinician.

Literature search shows that very few studies were published which discussed the localization of pain in the oral cavity region.[16-18] A major study was carried out by McCarthty et al. in 2010 discussing the importance of identification of painful tooth in an EE by patients in its diagnosis and emergency management. The study showed similar results as in our study and exhibited that the patient could identify the arch more accurately than identifying the correct painful tooth in SIP or SAAP cases.[19] Friend and Glenwright found that 79.3% patients could identify the offending tooth when one tooth mesial or distal side was considered as correct.[17] In a study by McCarthy, the tooth localization probability was observed to be 90.7% when one tooth on either side of the identified tooth would have been considered as correct.[19]

For assessing the pain severity, response to pain usually measured in verbal-numerical observation.[20] VNRS scale has been used in this study as it has been regarded as an acceptable and practical method for initial pain assessment (Table I).[4] As pain is a subjective phenomenon, it often varies from individual to individual, time to time and sometimes also differs in the same patient. Thus, initial pain scale reading would act as primary reading which may be used as a reference to compare with post-emergency management.

In our study, none of the patients have reported the pain crossing the midline and the results were same as in the study by Van Hassel and Harrington.[18] Conversely, in another study it was reported that pain has crossed the midline in 1.5% of the examined population may be due to cross-innervation.[17] Seltzer et al. in their study concluded that mandibular posterior teeth may cause pain in ear and temporal region on the ipsi-lateral side and usually cause referred pain to the other jaw.[21] Our study reported that there was a significant difference between tooth identified by patients and by the clinicians. In some situations where the patient is in severe pain, may confuse and misguide the dentist. If the clinician relies on the patient's chief complaint without carrying out necessary examinations and investigations; it may render the wrong treatment.

## Conclusion

Identification of pain source in the EE is a vital issue in the pain management. VNRS scale is a simple, quick and reproducible tool in pain assessment. Patient's certainty about the painful tooth may not always guide the clinician to conclude the diagnosis, especially in EE. Though, in some critical cases where patients could not identify painful tooth; the clinician's knowledge, judgement and experience would help to identify the offending tooth. Also, the spread of odontogenic infection to the periradicular area significantly increases the probability of identification of the painful tooth by the patients with severe odontalgia.

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Nil.

**Conflicts of interest**

There are no conflicts of interest.

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# Comparative analysis of dentinal tubule penetration of three different root canal sealers along with resilon and gutta-percha to root dentin - An in vitro SEM study.

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## Abstract

**Aim:** To evaluate the dentinal tubule penetration depth of three different sealers namely Zinc oxide Eugenol sealer, AH Plus and Epiphany with Resilon and Guttapercha core materials under SEM at various levels of radicular dentin.

**Materials and methods:** Forty five Single root mandibular premolars were collected considering inclusion and exclusion criteria. All the 45 specimens were randomly allocated into three groups as follows - Group I: Obturation was done using gutta-percha cones and zinc-oxide Eugenol sealer, Group II: Obturation was done using gutta-percha cones and Epoxy resin based AH Plus sealer. Group III: Obturation was done using Resilon cones and Epiphany SE sealer. The specimens were then subjected to SEM analysis after one week.

Photomicrographs of coronal, middle, and apical thirds of root canal were taken for sealer penetration at a magnification of x1000. The values obtained were measured in micron meters (µm) which were then subjected to statistical analysis.

**Results and Observations:** The tabulated observations were then statistically analysed using one way ANOVA at significant level of ($p<0.05$) at each third of the root canal that showed maximum penetration depth in the coronal third with statistically significant difference ($p<0.05$) between the three sealers.

**Conclusion:** The maximum penetration of all the three sealers was seen in the coronal third, least or negligible in the apical third with maximum depth of penetration was observed in Group III - Epiphany sealer.

**KeyWords:** AH plus sealer, Epiphany-Resilon, Resin Monoblock System, Scanning Electron Microscope, Zinc Oxide eugenol sealer.

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## Introduction

The aim of Endodontics is the preservation of tooth in the oral cavity to its function. It consist of endodontic triad containing access cavity preparation, cleaning shaping and three dimensional obturation of the canal.

The cleaning and shaping procedure is considered as one of the prime steps and requires instrumentation using endodontic instruments and activated irrigation. During instrumentation the generated smear layer may cover the prepared canal walls and occlude the dentinal tubules. Thus, complete elimination of microorganisms from the root canal is not achieved which ultimately affects the prognosis of root canal therapy.[1] Goldberg and Abramovich suggested that the smear layer might prevent the penetration of intracanal disinfectants and filling materials into dentinal tubules.[2] Studies concluded that the removal of the smear layer is mandatory in order to facilitate the adaptation of adhesive plastic root canal filling materials so as to promote the sealers to penetrate into dentinal tubules.[3,4,5]

Obturation of the root canal space eliminates all avenues of retrograde leakage into the root canal system by creating a fluid tight seal.[6] Usually, a core filling material is used in conjunction with root canal sealers to attain a fluid impervious seal between the core material and root canal walls[7] as most of the sealers exhibit the ability to penetrate into the accessory canals, lateral canals and dentinal tubules. Since ages, the material of choice as a sealer used in Endodontics is based on zinc oxide and eugenol formulations, but however the drawback is that they are not adhesive.[8] AH Plus on other hand (Epoxy – based sealer) is one of the most commonly used adhesive resin sealer. It has higher bond strength to dentin in comparison to zinc oxide – eugenol, glass ionomer and calcium hydroxide – based sealers.[9]

Resilon is a synthetic polymer based obturating material introduced in 2004[10,11] broadens the dimensions of endodontic adhesion. This system consists of a combination of primer, dual cure sealer and resin obturating material[12] and creates a mono-block effect. The Monoblock effects is created by the adhesion of Resilon cone to resin based sealer, which in turn adheres to the dentinal wall via penetrating into dentinal tubules.[10,13] Shipper et al. called it as "Resilon Monoblock System" (RMS) which has the potential to strengthen the root canal walls against the fracture and decrease the micro leakage.[14] The sealer cements within dentinal tubules also entombs the residual bacteria within the tubules and the chemical components of sealer may exert an antibacterial effect that will be enhanced by closer approximation to the bacteria.

Thus, this in-vitro study was conducted to compare the dentinal tubule penetration of three different root canal sealers - zinc oxide eugenol, AH Plus and Epiphany sealer with Resilon and Gutta-percha core materials, under Scanning Electron Microscope (SEM).

## Material and Method

In this invitro study, forty five single root mandibular premolars were collected from the Department of Oral and Maxillofacial Surgery, Government Dental College and Hospital, Mumbai. (Sample size- 45, margin of error 5, confidence level 95% and population size 50). The inclusion criterias were -sound teeth without caries and teeth with single and straight canals with fully developed apices. Teeth with open apices, cracks, curved and multiple canals, fractured teeth were excluded from the study.

The specimens were cleaned off soft tissue, calculus and stains with the help of scaler and were stored in 0.9% normal saline in a glass beaker till the time they were used further.

Decoronization of all 45 specimens was done using a double sided diamond disc under copious water cooling where coronal surface was perpendicular to the long axis of the root and the remaining root length was kept as 14mm using digital vernier calliper.

### Cleaning and shaping :

Working length was determined by placing a No.#10 K file into the root canal, until it was just visible at the apical foramen and then withdrawing it by 1 mm. The pulp tissue remnants were removed using barbed broach. The specimens were instrumented using Protaper Ni-Ti rotary instrument system. All the root canals were prepared to final apical size of F2. Copious irrigation was done using 5ml of 3% sodium hypochlorite (NaOCl) solution using a syringe and 27 gauge needle throughout instrumentation. All specimens were flushed with 1ml of 17% EDTA solution followed by 5ml of 3% sodium hypochlorite solution for 1 minute in order to remove the smear layer. This was followed by a final irrigation with 5ml of 0.9% Normal saline. Each of the root canal specimens were dried with the sterile paper points and kept ready for obturation.

All the 45 specimens were randomly allocated into three groups:

**Group I** : Obturation was done using gutta-percha cones and Zinc-oxide Eugenol sealer.

**Group II** : Obturation was done using gutta-percha cones and Epoxy resin based AH Plus sealer.

**Group III** : Obturation was done using Resilon cones and Epiphany SE sealer.

In Group III after obturation the coronal portion of the sealer was subsequently subjected to polymerization using light curing unit for 40 seconds. Excess material was seared-off at the root canal orifice and condensed with a plugger to 1mm below the canal orifice which are then sealed using Intermediate Restorative Material (IRM). The specimens in all the four groups were stored separately for 1 week at room temperature to allow sealer to set completely.

**Preparation of specimens for SEM examination :**

A slow speed, water- cooled diamond impregnated disc was used to section the specimens parallel to their long axis, resulting into two specimens per tooth. One segment from each split specimen was selected and was prepared for SEM examination. The surface of all the specimens was demineralized with 10 minutes application of 17% EDTA. A further 10 minutes application of 3% NaOCl was used to remove debris and the surface layer of organic matrix around the sealer tags.

The specimens were then washed with distilled water and air dried. The specimens were then desiccated using graded concentration (30%, 50%, 70% 90%, 100%) of ethanol. All the specimens were vacuum dried and mounted onto existing aluminium stubs. The specimens were sputter coated with a thin gold coating using Gold sputtering machine and examined under Scanning Electron Microscope.

Photomicrographs of coronal, middle, and apical thirds of root canal were taken at a magnification of x1000 and maximum depth of sealer penetration was measured in µm at coronal, middle and apical thirds of root canal. The values obtained were measured in micron meters (µm). The results were tabulated and subjected to statistical analysis.
[Table I- XV]

**TABLE – I**

Penetration Depths In Micron Meters Of Group – I (Zinc-oxide Eugenol) At Various Thirds Of Root Canal

| Sample | Coronal third | Middle third | Apical third |
|---|---|---|---|
| 1 | 13 im | 13 im | 04 im |
| 2 | 18 im | - | - |
| 3 | 17 im | 14 im | - |
| 4 | 18 im | 10 im | 03 im |
| 5 | 21 im | - | - |
| 6 | 18 im | 11 im | 02 im |
| 7 | 17 im | 12 im | 06 im |
| 8 | 20 im | - | - |
| 9 | 19 im | 10 im | 05 im |
| 10 | 18 im | - | - |
| 11 | 15 im | 13 im | - |
| 12 | 20 im | 10 im | 02 im |
| 13 | 18 im | - | 04 im |
| 14 | 17 im | 12 im | - |
| 15 | 20 im | 11 im | 03 im |

**TABLE – II**

Penetration Depths In Micron Meters Of Group – II (AH Plus) At Various Thirds Of Root Canal

| Sample | Coronal third | Middle third | Apical third |
|---|---|---|---|
| 1 | 49 im | 18 im | 16 im |
| 2 | 47 im | 20 im | - |
| 3 | 50 im | 26 im | 13 im |
| 4 | 52 im | 29 im | 12 im |
| 5 | 53 im | 42 im | 14 im |
| 6 | 57 im | 22 im | - |
| 7 | 55 im | 35 im | - |
| 8 | 53 im | 22 im | 13 im |
| 9 | 48 im | 24 im | - |
| 10 | 52 im | 20 im | 09 im |
| 11 | 52 im | 20 im | 13 im |
| 12 | 46 im | 34 im | 10 im |
| 13 | 42 im | 26 im | - |
| 14 | 48 im | 32 im | 11 im |
| 15 | 50 im | 30 im | 09 im |

**TABLE – III**

Penetration Depths In Micron Meters Of Group – III (Resilon-Epiphany) At Various Thirds Of Root Canal

| Sample | Coronal third | Middle third | Apical third |
|---|---|---|---|
| 1 | 52 im | 44 im | 30 |
| 2 | 60 im | 36 im | 32 |
| 3 | 56 im | 32 im | 26 |
| 4 | 62 im | 37 im | 23 |
| 5 | 57 im | 22 im | 19 |
| 6 | 58 im | 21 im | 18 |
| 7 | 56 im | 18 im | 16 |
| 8 | 53 im | 20 im | 19 |
| 9 | 55 im | 24 im | 17 |
| 10 | 58 im | 35 im | 22 |
| 11 | 51 im | 34 im | 28 im |
| 12 | 49 im | 26 im | 22 im |
| 13 | 52 im | 28 im | 24 im |
| 14 | 54 im | 27 im | 26 im |
| 15 | 56 im | 32 im | 21 im |

**TABLE - IV**

Maximum Penetration Depth ( in µm) Of Zoe, AH Plus, and Epiphany Sealers

| Sample | ZOE | AH Plus | Resilon-Epiphany |
|---|---|---|---|
| 1 | 13 im | 49 im | 52 im |
| 2 | 18 im | 47 im | 60 im |
| 3 | 17 im | 50 im | 56 im |
| 4 | 18 im | 52 im | 62 im |
| 5 | 21 im | 53 im | 57 im |
| 6 | 18 im | 57 im | 58 im |
| 7 | 17 im | 55 im | 56 im |
| 8 | 20 im | 53 im | 53 im |
| 9 | 19 im | 48 im | 55 im |
| 10 | 18 im | 52 im | 58 im |
| 11 | 15 im | 52 im | 51 im |
| 12 | 20 im | 46 im | 49 im |
| 13 | 18 im | 42 im | 52 im |
| 14 | 17 im | 48 im | 54 im |
| 15 | 20 im | 50 im | 56 im |

**TABLE -V**

Table Showing Mean, Standard Deviation, Standard Error In Coronal Third Of All The Three Sealers

| | N | Mean | Std. Deviation | Std. Error |
|---|---|---|---|---|
| ZOE | 15 | 17.9000 | 2.13177 | .67412 |
| Resilon | 15 | 56.7000 | 3.02030 | .95510 |
| AH Plus | 15 | 51.6000 | 3.13404 | .99107 |
| Total | 45 | 42.0667 | 17.71602 | 3.23449 |

**TABLE – VI**

Table Showing Mean, Standard Deviation, Standard Error In Middle Third Of All The Three Sealer

| | N | Mean | Std. Deviation | Std. Error |
|---|---|---|---|---|
| ZOE | 15 | 7.0000 | 6.14636 | 1.94365 |
| Resilon | 15 | 28.9000 | 8.96227 | 2.83412 |
| AH Plus | 15 | 25.8000 | 7.58361 | 2.39815 |
| Total | 45 | 20.5667 | 12.30274 | 2.24616 |

**TABLE-VII**

Table Showing Mean, Standard Deviation, Standard Error In Apical Third Of All The Three Sealers

| | N | Mean | Std. Deviation | Std. Error |
|---|---|---|---|---|
| ZOE | 15 | 5.0000 | 2.13936 | 1.00045 |
| Resilon | 15 | 19.2000 | 5.96271 | 1.45412 |
| AH Plus | 15 | 12.3100 | 3.58001 | 1.21815 |
| Total | 45 | 9.5783 | 6.76274 | 1.12616 |

**TABLE-VIII**

Analysis Of Variance (one-way Anova) Coronal Third

| | Sum of Squares | d.f. | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 8890.467 | 2 | 4445.233 | 567.745 | .000 |
| Within Groups | 211.400 | 27 | 7.830 | | |
| Total | 9101.867 | 29 | | | |

**TABLE-IX**

Analysis Of Variance (one-way Anova) Middle Third

| | Sum of Squares | d.f. | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 2808.867 | 2 | 1404.433 | 23.992 | .000 |
| Within Groups | 1580.500 | 27 | 58.537 | | |
| Total | 4389.367 | 29 | | | |

**TABLE-X**

Analysis Of Variance (one-way Anova) Apical Third

| | Sum of Squares | d.f. | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 1606.845 | 2 | 1091.421 | 16.092 | .000 |
| Within Groups | 1079.245 | 27 | 26.217 | | |
| Total | 2456.231 | 29 | | | |

**TABLE-XI**

Post Hoc Tests Multiple Comparisons In Coronal Third

| (I) group | (J) group | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| Resilon | AH Plus | 5.10000(*) | 1.25137 | .000 |
| | ZOE | 38.80000(*) | 1.25137 | .000 |
| AH Plus | Resilon | -5.10000(*) | 1.25137 | .000 |
| | ZOE | 33.70000(*) | 1.25137 | .000 |
| ZOE | Resilon | -38.80000(*) | 1.25137 | .000 |
| | AH Plus | -33.70000(*) | 1.25137 | .000 |

* The mean difference is significant at the .05 level.

**TABLE-XII**

Post Hoc Tests Multiple Comparisons In Middle Third

| (I) group | (J) group | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| Resilon | AH Plus | 1.10000 | 3.42161 | .373 |
| | ZOE | 16.90000(*) | 3.42161 | .000 |
| AH Plus | Resilon | -1.10000 | 3.42161 | .373 |
| | ZOE | 12.20000(*) | 3.42161 | .000 |
| ZOE | Resilon | -16.40000(*) | 3.42161 | .000 |
| | AH Plus | -10.18000(*) | 3.42161 | .000 |

* The mean difference is significant at the .05 level.

**TABLE-XIII**

Post Hoc Tests Multiple Comparisons In Apical Third

| (I) group | (J) group | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| Resilon | AH Plus | 3.10000 | 4.34161 | .142 |
| | ZOE | 21.90000(*) | 4.34161 | .000 |
| AH Plus | Resilon | -3.10000 | 4.34161 | .142 |
| | ZOE | 18.80000(*) | 4.34161 | .000 |
| ZOE | Resilon | -21.90000(*) | 4.34161 | .142 |
| | AH Plus | -18.80000(*) | 4.34161 | .142 |

* The mean difference is significant at the .05 level.

**TABLE-XIV**

Analysis Of Variance (one-way Anova)
Maximum Penetration Depth ( in µm)
In Epiphany, Ah Plus, And Zoe

| | Sum of Squares | d.f. | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 8890.467 | 2 | 4445.233 | 567.745 | .000 |
| Within Groups | 211.400 | 27 | 7.830 | | |
| Total | 9101.867 | 29 | | | |

**TABLE-XV**

Multiple Comparisons Maximum Penetration Depth (in mm)
In Epiphany, Ah Plus And Zoe

| (I) group | (J) group | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| Resilon | AH Plus | 5.10000(*) | 1.25137 | .000 |
| | ZOE | 38.80000(*) | 1.25137 | .000 |
| AH Plus | Resilon | -5.10000(*) | 1.25137 | .000 |
| | ZOE | 33.70000(*) | 1.25137 | .000 |
| ZOE | Resilon | -38.80000(*) | 1.25137 | .000 |
| | AH Plus | -33.70000(*) | 1.25137 | .000 |

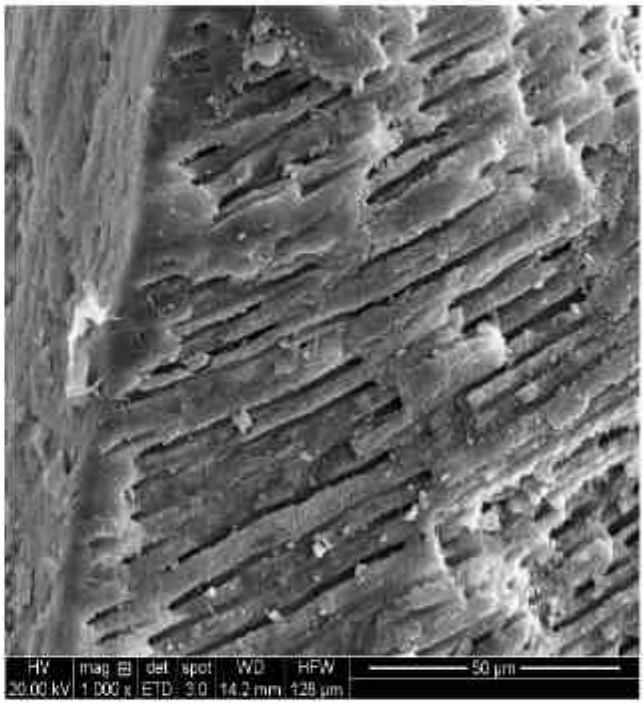
* The mean difference is significant at the .05 level.

## Results

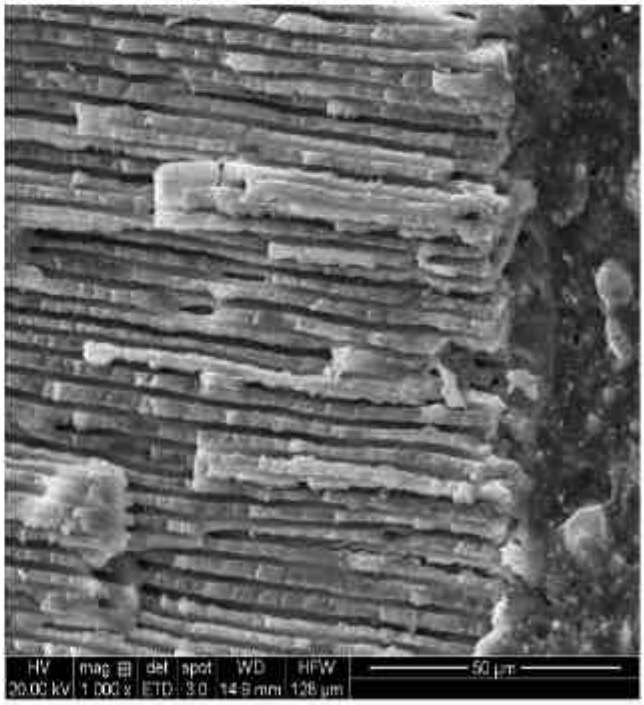
**Group I (Zinc-Oxide Eugenol):**

On examination under SEM, the sealer particles were large, spherical with limited penetration upto 21µm, 14µm and 6µm in coronal, middle and apical third respectfully (Photomicrograph 1A, 1B, 1C)

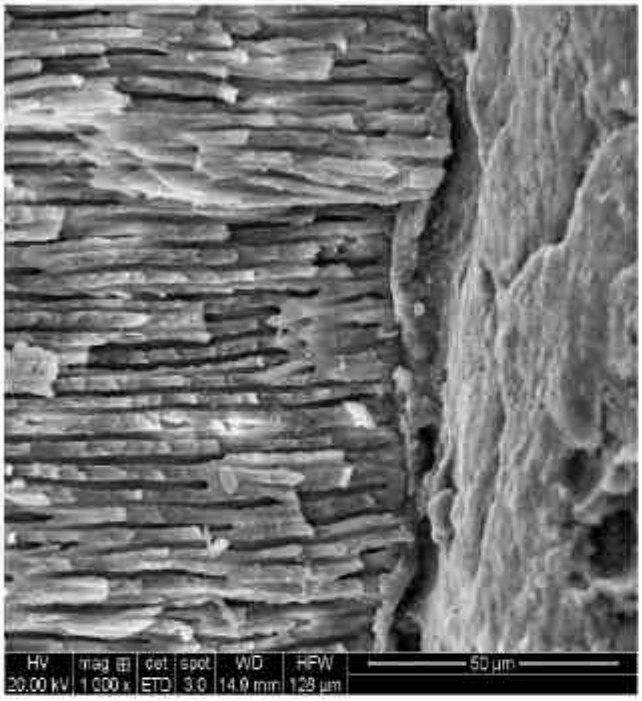
**Photomicrograph 1 A:**
SEM Photomicrograph of Group I at Cervical third




**Photomicrograph 1 B:**
SEM Photomicrograph of Group I at Middle third



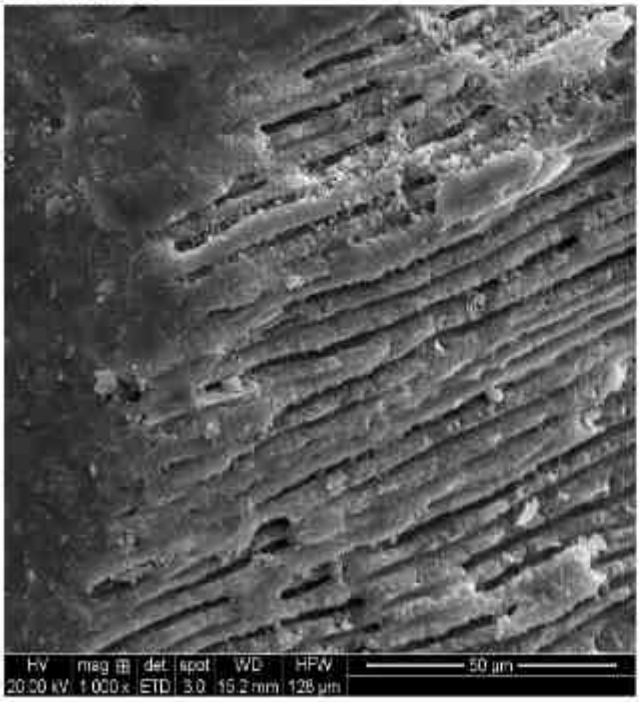
**Photomicrograph IC:**
Sem Photomicrograph of Group I at Apical Third



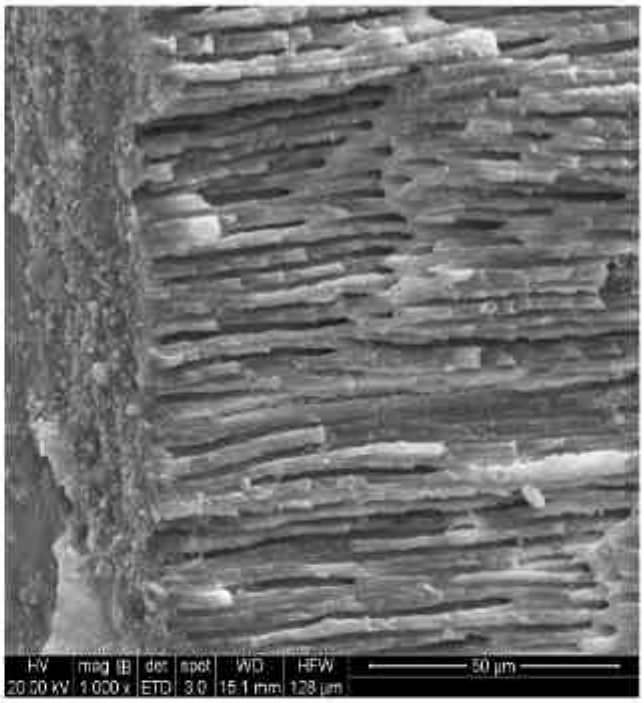

**Group II ( AH Plus):**

The appearance of the sealer was granular with maximum penetration upto 57µm, 42µm and 16µm in coronal, middle and apical third respectfully (Photomicrograph IIA, IIB, IIC)

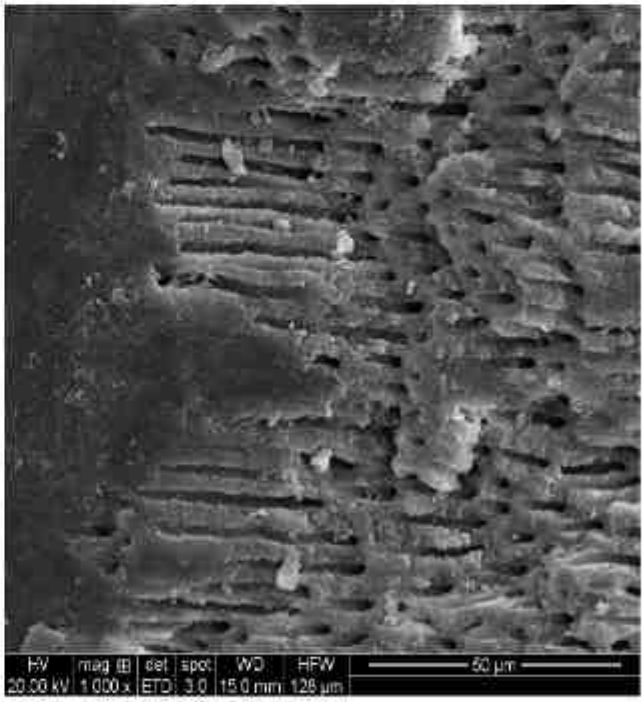
**Photomicrograph II A:**
SEM Photomicrograph of Group II at Coronal third




**Photomicrograph II B:**
SEM Photomicrograph of Group II at Middle third




**Photomicrograph II C:**
SEM Photomicrograph of Group II at Apical third

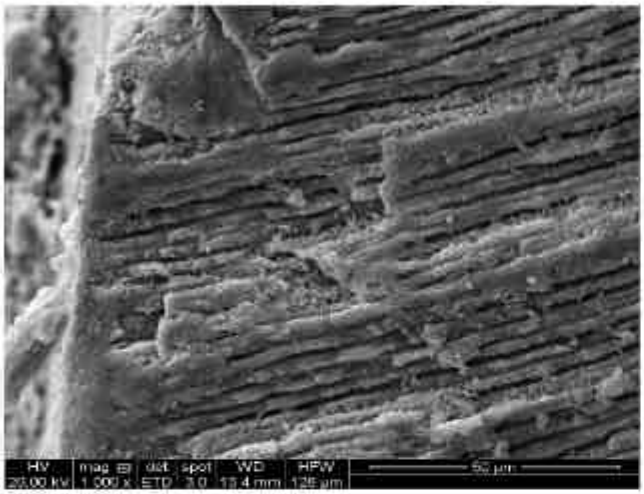



**Group III ( Resilon-Epiphany):**

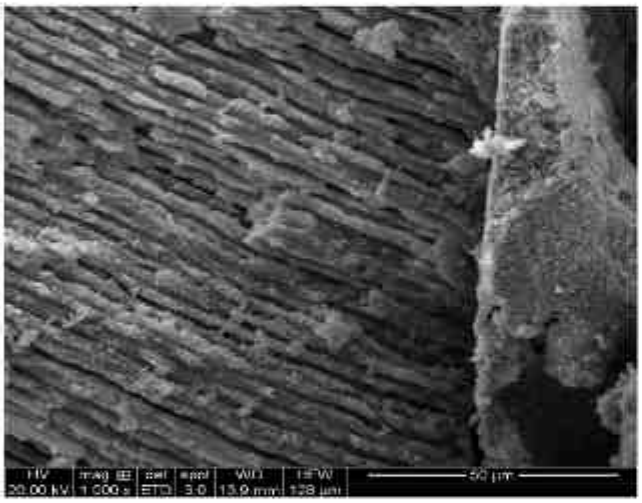
The appearance of the scaler was granular with maximum penetration upto 62µm, 44µm and 32µm in coronal, middle and apical third respectfully

(Photomicrograph IIIA, IIIB, IIIC)

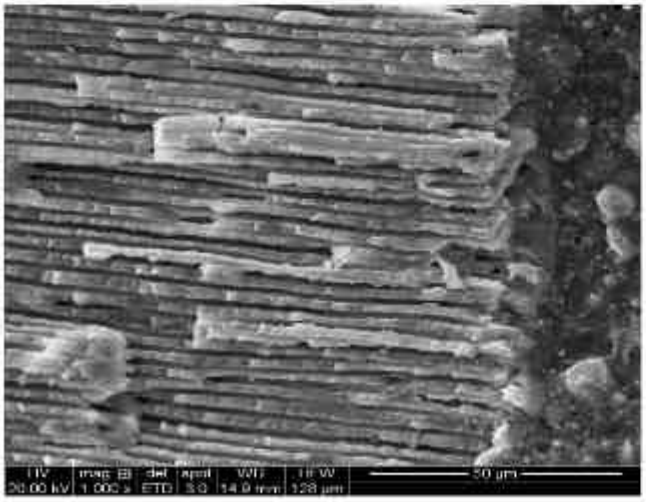
**Photomicrograph 3 A:**
SEM Photomicrograph of Group III at Coronal third



**Photomicrograph 3 B:**
SEM Photomicrograph of Group III at Middle third



**Photomicrograph III C:**
SEM Photomicrograph of Group III at Apical third

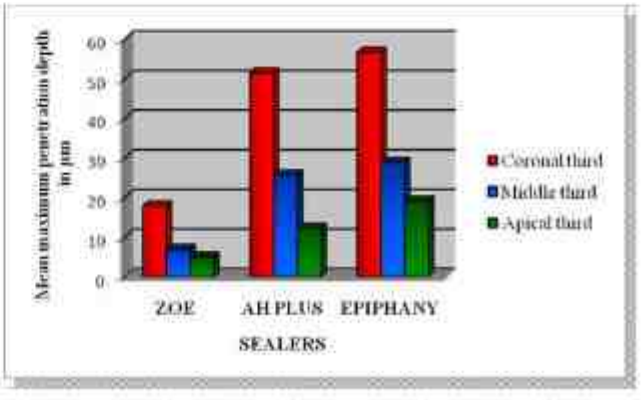


The tabulated observations were then statistically analysed using one way ANOVA at significant level of ($p<0.05$) at each third of the root canal. It was found that all the three sealers showed maximum penetration depth in the coronal third with statistically significant difference ($p<0.05$) between the three sealers.

Post Hoc test was also performed, to compare the variation of maximum penetration depth of sealer tested between the groups. In comparison to Group I (Zinc Oxide Eugenol sealer), Group II (AH Plus) and Group III (Epiphany) showed highly statistical significant difference. Group II and Group III also showed statistical significant difference.

**GRAPH I**
Graphical Representation Of The Maximum Penetration Depth ( in mm) Of Zoe, AH Plus, And Epiphany Sealers


**GRAPH II**
Graphical Representation Of The Mean Maximum Penetration Depth ( In Mm) Of Zoe, AH Plus, And Epiphany Sealers



## Discussion

Three dimensional obturation of the root canal is one the main goals of endodontic treatment essential for preventing reinfection of the canal and to preserve the health of the periapical tissues, thereby ensuring the success of root canal therapy.[1]

Root canal sealers play an integral role in obturation and are important to attain an impervious fluid tight seal between the core material and root canal walls. Over the past century, gutta-percha (GP) combined with zinc oxide eugenol sealer has been the most commonly used obturation system and has served as a benchmark when evaluating newer materials.[13]

However, GP and ZOE sealer does not have adaptation to the root canal walls and does not form a 'monoblock' thereby may exhibit microleakage and various studies have exhibited leakage at their interface.[16,17] Due to these limitations, the newer materials are introduced to form a seal along the radicular dentin which is important in preventing re-infection of the root canal space.

Resin sealers and synthetic root canal filling material were introduced and their design is based on polyester chemistry and these exhibit looks and handles similar to gutta percha [3]. Studies have shown that bacterial leakage with Resilon is significantly less when compared with gutta-percha.[18] Resin sealers have shown to penetrate into the dentinal tubules much more than the conventional sealers[3,13]. This study was undertaken to evaluate the penetration depth of 3 sealers - Zinc oxide Eugenol, AH Plus and Epiphany sealer with Resilon and Guttapercha core materials into the dentinal tubules using a Scanning Electron Microscope (SEM).

Over the years, SEM have been used by a number of investigators to evaluate the sealer penetration into dentinal tubules.[10,19,20,21,22,23] The images produced using SEM allows for detailed observation of the dentinal tubules, the integrity and surface appearance of the sealer cement[3]. The penetration of the sealer into the dentinal tubules can be seen in detail and at high magnification.[4]

Instrumentation during root canal therapy produces a 1-5 µm thick smear layer. Mc Comb and Smith were the first to describe the smear layer on instrumented root canal walls[5].

Proponents state that the removal of the smear layer allows for intimate contact of irrigants, medicaments and sealers with the potentially infected dentinal tubules.[5,13,20,21] The smear layer plays an important role in root canal therapy because it affects the adaptation of filling materials to the root canal walls. Many studies conclude that the removal of the smear layer is mandatory for the adhesive root canal filling materials and sealers to penetrate dentinal tubules.[1,21,24] Application of EDTA and NaOCl removes the smear layer completely and allows all sealers to penetrate into the dentinal tubules, although to a varying depths.[3,23]

SEM analysis has shown that the smear layer comprises of both organic and inorganic substances. The components of the smear layer are very small particles with a large surface-mass ratio, which makes them very soluble in acids. Goldmen et al (1982) showed that when used alone, EDTA removed the inorganic portion and left an organic layer intact in the tubules [25]. NaOCl has been shown to be effective in dissolving pulpal remnants and predentin. The tubule orifices are enlarged due to the dissolution of peritubular dentin [3]. Various concentrations of NaOCl have been used to remove the smear layer in clinical endodontic practice. Studies have shown that 3%NaoCl removed the smear layer, bacteria and organic tissue satisfactorily[26] which is a strong oxidizing agent and may cause problems when used as the last irrigant. It leaves behind an oxygen rich layer on the dentin surface, which results in reduced bond strengths by inhibiting the polymerization of resins and increased microleakage.

Therefore ,it has been proposed to use NaOCl first, followed by EDTA for removal of the smear layer after the instrumentation, and then distilled water as a final rinse in order to minimize the compromising effect of NaOCl on primer/resin-sealer polymerization, and to achieve better adhesion of the sealers by permitting penetration of sealers into dentine tubules.[3,27]

According to Ingle[28] lateral condensation of guttapercha is the most widely used method of obturating root canals which is in accordance with the present study where root canal obturation was done by lateral condensation technique because it is a most widely recommended and a proven classic technique.[29,30]

Penetration of endodontic sealers into dentinal tubules decreases the interface between the material and the dentin and exert antibacterial effects against bacteria that reside within these areas has been well established.[31,32] Sealers that display greater penetration will potentially have a greater propensity to entomb viable bacteria within tubules, isolating them from potential nutrient sources.

The penetrability of resin sealers into accessory and lateral canals may be a function of their physical properties like flow, surface tension, solubility, working and setting time.[3,33] Flow is important as it reflects its ability to penetrate into small irregularities and ramifications of the root canal system and dentinal tubules and enter un-instrumented accessory root canal anatomy.[34]

Moreover, flow along with the sealer's antimicrobial effectiveness may aid the disinfection of the root canal system. Most endodontic sealers are psuedoplastic so that viscosity is reduced and flow is increased when shear rate increases during compaction [35]. This should facilitate sealer flow into accessory anatomy. Physically the penetration of a liquid (uncured resin) into a porous solid (dentin) is described by Washburn equation [36]. This equation assumes that the porous solid is a bundle of open capillaries; in this case the penetration of the liquid is driven by capillary force.[37]

Surface tension of filling materials determines the depth of their penetration into dentinal tubules: the lower the tension, the higher the penetration level [24,38,39] and this could conceivably improve the sealing ability of the root canal system by increasing the surface area contact of filing materials to prepared canal walls [26,40].

Polymerization shrinkage is often associated with resin sealers. Cavity configuration factor (c-factor) is the ratio of the bonded to unbounded surface area[7] where the volume of monomers is reduced, which creates sufficient shrinkage stresses to debond the material from the dentin, thereby decreasing retention and increasing leakage. As the thickness of the adhesive material or sealer is reduced, the volumetric shrinkage is reduced, which results in a reduction of shrinkage stress(s-factor).[41]

Within the limitations of the present study, the least depth of penetration amongst the three groups was witnessed in Group I and the mean depth of penetration seen in the coronal third was 21µm, 14µm in the middle third, 6µm at the apical third whereas Group II had a more penetration compared to Group I but showed les penetration when compared to Group III with a mean penetration of 57µm at the coronal third, 42µm at the middle third, 16 µm at the apical third.

Group III exhibited the maximum penetration depth into the radicular dentinal tubules compared to Group I and Group II. The mean depth of penetration at the coronal third was 62µm, 44m at the middle third, 32 µm at the apical third.

Kokkas et al.(2004)[29] examined the influence of the smear layer on dentinal tubule penetration depth of AH Plus, Apexit, and Roth 811 root canal sealers where AH plus displayed deeper penetration than the zinc oxide eugenol (ZOE) based sealer which was in accordance with the present study.

Gharib et al. (2007)[4] assessed the resin dentin interface and compared the average depth of dentin tubule sealer penetration in the coronal, middle and apical third of anterior teeth obturated with Epiphany obturation system using Confocal microscopy and showed that there was significantly less percentage of sealer penetration in the apical sections than the middle or coronal section. The results of present study coincide with this study showing maximum penetration of the sealers at the coronal third, followed by the middle third and minimal in the apical third.

Regional variation in the depth of tubular penetration has been demonstrated by a number of authors.[17,19,22,38] The apical dentin displays less tubule density with some areas completely devoid of tubules exhibit sclerosis of dentin which may prevent penetration of irrigating solutions and root canal sealers.[16,42,43]

A primer is used to condition the walls of the root canal prior to the sealer application that opens the dentinal tubule by removing the smear layer, thus facilitating greater amount of penetration into the dentinal tubules. In the sealers that were tested Only Resilon-Epiphany is to be used with a self etching primer prior to the application of the sealer.[4,11] Therefore probably a greater penetration at all the three levels was seen with Group III-Resilon-Epiphany due to the application of self etching primers.

With the other sealers, primers are not to be used; therefore the penetration may be dependent on the smear layer removal by 17% EDTA and the physical properties of the sealer. AH –Plus and ZOE have a reasonable setting time and their flow properties enable them to penetrate into the dentinal tubules. The type, size and shape of the fillers may also play an integral role and influence the penetration of resin sealers.

Incorporating nanofillers into newer sealers may enhance their penetration into the radicular dentinal tubules and help in decreasing the sealer - dentin interface. However Further studies are required to substantiate these results.

## Conclusion

**The following conclusions were drawn from this study:**

1. The maximum penetration of all the three sealers was seen in the coronal third, followed by the middle third and least or negligible in the apical third.
2. Among the sealers tested, the maximum depth of penetration in the radicular dentinal tubules was observed in Group III - Epiphany sealer.
3. Group – II AH Plus sealer had significantly greater penetration into dentinal tubules compared to Group I – Zinc Oxide Eugenol sealer but penetration was significantly less as compared to Group III - Epiphany sealer.
4. Group I – Zinc Oxide Eugenol sealer showed significantly minimum penetration compared to Group I – AH Plus sealer and Group III – Epiphany sealer.

Resilon is susceptible to alkaline hydrolysis by bacterial/salivary enzymes and endodontically relevant bacteria[21] that warrants further investigation in order to have further insight to the effectiveness of these materials.

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**Conflicts of interest**

There are no conflicts of interest.

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# Comprehensive Endodontic, Surgical and Esthetic Management of Amelogenesis Imperfecta Associated with Infected Radicular Cyst – A Rare Case Report

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## Abstract

Radicular cyst is the most common odontogenic cyst comprising about half of the entire jaw cysts. It is usually asymptomatic but may exhibit pain and swelling when secondarily infected. Management of the radicular cyst involves non-surgical root canal treatment of affected teeth or surgical enucleation when the lesion is non-responsive to conventional root canal therapy. This article presents successful management of a patient diagnosed with Amelogenesis Imperfecta (AI) associated with infected radicular cyst by conventional endodontic and surgical approach as well as its esthetic rehabilitation.

**Keywords** : Amelogenesis Imperfecta, Mineral Trioxide Aggregate, Periapical Surgery, Radicular Cyst.

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## Introduction

Radicular cyst is the most common odontogenic cyst derived from the Epithelial cell rests of Malassez.[1] It occurs as a consequence to inflammation usually caused by trauma to the upper anterior teeth. It is primarily asymptomatic and discovered as an incidental finding during routine radiographic examination.[2] Management of radicular cyst is done either by non-surgical or surgical approach. Though, nonsurgical endodontic treatment is highly predictable and a proven successful treatment modality in most of the cases, surgical approach is required in cases of large true cysts or persistent inflammatory cyst non-responsive to the nonsurgical approach.[1,2] Besides trauma, radicular cyst may also be associated with carious teeth having chronic periapical lesion of endodontic origin.

Amelogenesis Imperfecta (AI) is a rare, congenital developmental defect of enamel formation which presents with discoloured or pitted, yellowish appearance of the teeth. This case report describes the successful management of infected radicular cyst in a patient associated with amelogenesis Imperfecta AI by conservative and surgical approach.

## Case Report

A 30-year-old female patient was referred to the Department of Conservative Dentistry and Endodontics Government Dental College & Hospital, Mumbai from a private dental practitioner with a chief complaint of pain and swelling in the upper left front teeth region since 2 months. Pain was dull and intermittent in nature. She visited a local dental practitioner for the same and underwent root canal treatment of teeth #21 and #22. Unfortunately, even after initiation of root canal treatment of teeth #21 and #22, there was continuous pain and pus discharge through the same teeth and a fluctuant palatal swelling was observed in the maxillary left incisor region. Thus, the patient was referred to our tertiary care center for opinion and further treatment.

Clinically, the teeth #21 and #22 showed increased response to percussion and palpation test. The overlying palatal bone in this region appeared to be expanded without any defined border. The teeth exhibited no response to electric pulp testing. Her medical history was non-contributory and she gave no history of trauma to the affected teeth. Intraoral examination showed generalized loss of enamel and dentin with generalized yellowish discoloration affecting almost all the permanent teeth **[Figure 1]**.

Figure I: Clinical photograph showing generalized yellowish discoloured teeth.

Clinically, the enamel structure was lost leaving behind the residual crown structure composed mainly of the dentin. Translucency of enamel could not be demarcated and generalized attrition with loss of proximal contacts and vertical dimension was also observed, suggesting AI. She gave a history of similar kind of yellowish dentition in her family members suggestive of hereditary AI.

Intraoral periapical (IOPA) radiograph showed presence of well-defined, non-corticated, periapical radiolucency (approximately 18mm x15mm) in the region of tooth #21 and #22 **[Figure II]**.

Figure II : Preoperative IOPA radiograph showed well-defined periapical radiolucency associated with tooth #21, #22.

Aspiration of the swelling was performed using 20-gauge needle with 10cc syringe assembly. The collected yellowish discharge was sent for the histo-pathologic examination. Histo-pathological evaluation showed that the smear comprised predominantly of neutrophils admixed with lymphocytes, clusters and sheets of hemosiderin laden macrophages in a background of few RBCs, cholesterol crystals and proteinaceous material. Biochemical analysis revealed total protein: 359 mg/dl, Sugar: 34 mg/dl, Cholesterol: 238 mg/dl. From clinical, radiographic and histologic findings the diagnosis of infected radicular cyst associated with teeth #21 and #22 was made.

The differential diagnosis of infected radicular cyst involve periapical granuloma, periapical abscess or suppurative osteomyelitis. Usually, acute apical abscess manifests severe pain, swelling, tooth mobility and radiograph may show ill-defined radiolucency with hazy borders. In contrast, radicular cyst shows a well-defined radiolucency with the corticated border. But, if the cyst becomes secondarily infected, inflammatory reaction of surrounding bone may result in loss of cortication. This case presented with well-defined radiolucency, loss of cortication and palatal plate expansion suggesting the infected radicular cyst.

Root canal treatment of all sensitive and affected teeth was planned and after explaining the treatment procedures the informed consent was obtained from the patient.In the first visit, the access was modified in tooth #21 and #22. Pus discharge was observed through the root canal of tooth #21. Cleaning and shaping was performed. Irrigation with 5.25% sodium hypochlorite followed by saline and final rinsing with 2% chlorhexidine was done. Calcium hydroxide intra-canal dressing was given in both teeth #21and #22 and the patient was recalled after 7 days. In the next visit, the patient was symptomatic but showed pus discharge through the root canal of tooth #21. Intra canal irrigation was done with chlorhexidine and calcium hydroxide dressing was given. Patient was recalled again after a week.

In the subsequent visit, the tooth #22 was asymptomatic; but tooth #21 still showed the pus discharge. In this visit the tooth #22 was obturated. After irrigation, Triple Antibiotic Paste (TAP) comprising of combination of ciprofloxacin, metronidazole and cefixime (1:1:1 with saline) was placed in the root canal of tooth #21 and patient was recalled after 14 days. Two weeks later, slight pus discharge was still observed from the root canal of tooth #21 and the patient also presented with a palatal swelling. As, the lesion was non-responsive to the conservative approach, surgery was planned which include surgical enucleation, apicectomy and retrograde filling with Mineral Trioxide Aggregate (MTA). The root canal treatment of teeth #21 and #22 was completed one day prior to the scheduled surgery **[Figure III].**

Figure III: Post obturation IOPA radiograph of teeth #21 and #22 before surgery.

Pre-surgical blood investigations were performed to check general fitness of the patient. All the procedures were described to the patient and her informed consent was obtained. Infra-orbital nerve block, naso-palatine nerve block and local infiltration of surgical site was done using 2% lignocaine containing 1:80,000 epinephrine. After securing profound anaesthesia, two vertical incisions and one horizontal incision extending from left maxillary canine to right maxillary lateral incisor were given using No.15 blade. Full thickness muco-periosteal flap was elevated with the help of periosteal elevator. A large bony defect was observed, perforating the labial cortical plate. Surgical SS white bur was used along with the coolant to widen the bony window and remove the defective margins.The granulation tissue was removed using the curette after enucleation **[Figure IV]**.

Figure IV : Surgical curettage followed by enucleation.

After complete curettage of cystic lesion, it was sent for the histo-patholgic examination; which confirmed it as the "Infected radicular cyst" **[Figure V]**.

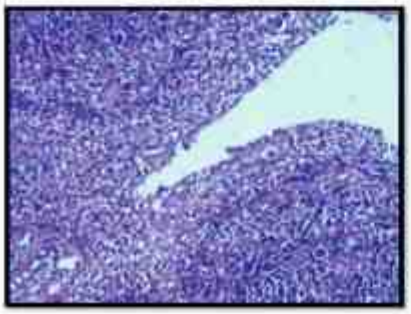

Figure V: Histologic photograph of infected radicular cyst.

The apex of the tooth #21 was resected **[Figure VI]**

Figure VI : Root end resection and retro-grade cavity preparation in tooth #21.

and root end cavity was prepared with ProUltra ultrasonic tips No. 1 and No.2 (Dentsply Maillefer, Switzerland) to a depth of 3 mm and retrograde filling was done using MTA (Angelus) **[Figure VII]**.

Figure VII: Retrograde filling with MTA in teeth #21 and #22.

Immediate post-surgical IOPA radiograph was made. **[Figure VIII]**.

Figure VIII: Immediate post-surgical radiograph of teeth #21 and #22.

After proper approximation, flap closure was done with polyester suturing material using simple interrupted suturing technique. Post-operative instructions were given and the patient was recalled after 7 days for the suture removal. As per the patient's esthetic demand, esthetic rehabilitation of patient was done after root canal treatment of all teeth, followed by esthetic crowns **[Figure IX]**.

Figure IX: Esthetic rehabilitation of all teeth

Patient was advised to report back every 3 months for regular follow up in which IOPA showed satisfactory healing **[Figure X].**

Figure X: 3 months follow-up IOPA radiograph of teeth #21 and #22 showing satisfactory healing of the lesion.

## Discussion

Radicular cyst is the most common odontogenic inflammatory jaw cyst, also known as periapical cyst. Its prevalence is about 52% to 68% of all the jaw cysts.[1] It arises from epithelial remnants in the periodontal ligament as a result of inflammation.[2] It is always associated with a non-vital tooth. Dental caries or trauma to the teeth causes inflammation of the pulp and leads to pulp necrosis.[3] However, in this case, patient neither presented with caries, nor gave any history of trauma. The occurrence of a radicular cyst here can be attributed to the early loss of enamel owing to AI exposing the dentinal tubules to bacterial invasion causing the pulpal inflammation and the necrosis. The infection then spread to the apex of the tooth, causing periapical periodontitis; which may have lead to proliferation of epithelial rest cells in the periodontal ligament leading to formation of the radicular cyst.[4]

Radicular cyst is of two types "pocket cyst" (attached to the apical foramen) or "true cyst" (no attachment to the root structure).[5] The presented case demonstrate a classic true cyst. It is usually asymptomatic and discovered incidentally on radiographic examination. It may cause swelling or pain in cases when the cyst is large or secondarily infected, as seen in our case.[6] Radiographic presentation of radicular cyst includes, corticated pear-shaped, unilocular radiolucent area in the periapical region of the involved teeth. The cortication, in this case was lost owing to inflammatory reaction of the surrounding bone due to secondary infection. The cyst often displaces the adjacent teeth or cause root resorption, but neither have been exhibited in this case.[7]

Histologically, it shows cystic cavity lined by non-keratinized stratified squamous epithelium supported by connective tissue capsule. The connective tissue capsule consists of dense bundles of collagen fibres with interspersed fibroblasts, dense inflammatory cell infiltrate chiefly consisting of lymphocytes, plasma cells and extravasated red blood cells.[8] This case presented with infected radicular cyst in a patient with AI. AI is a congenital defect of enamel formation, which is characterized by presence of small, yellow, brown teeth that are prone to damage and breakage.[9,10] AI is of three types hypoplastic, hypocalcified, and hypomaturation. In this case, the patient presented with hypocalcified AI affecting enamel in colour, thickness and resistance and manifesting as small, yellowish brown teeth. This patient had no history of trauma. So in this case, exposed dentine might have provided pathway for bacterial entry into periapical area that resulted in apical periodontitis and subsequent cyst formation that was detected when patient came with palatal swelling in maxillary front teeth region.

The choice of treatment of radicular cyst may be determined by factors such as the extension of the lesion, relation with anatomic structures, origin, and clinical characteristics of the lesion, and co-operation and systemic condition of the patient.[11] Treatment is directed at eliminating the etiology which most often is the presence of bacteria and other microbial irritant in the root canal system. Various treatment options for management include conventional root canal treatment without any adjunctive therapy or use of intracanal medicament as an adjunct to the root canal treatment, surgical treatment like decompression, apex, enucleation or marsupialization. Various studies have reported 85% success rate after non surgical endodontic treatment of teeth with periapical lesion.[12]

In this case, one of the involved teeth was non-responsive to the non-surgical root canal treatment. So, surgical approach was planned which included enucleation and retrograde filling with MTA. Enucleation involves complete removal of cystic lining with healing by primary intention.[13]

MTA is a widely accepted retrograde filling material which is biocompatible, has better sealing ability and is resistant to displacement.[14] Follow-up was taken after three months which showed expected healing of the cystic lesion with bone formation.

In cases of AI due to loss of enamel, the teeth may become sensitive and become susceptible to infection due to open dentinal tubules. In our case, considering the esthetic demands of the patient and overall clinical condition of the patient's teeth as AI, root canal treatment of all teeth was planned and esthetic full coverage restoration were given to the patient.

## Conclusion

Radicular cysts are usually associated with trauma and often detected as incidental findings during routine dental radiographic examination. Small cystic lesions though frequently heal simply after proper endodontic therapy; some true lesions are non-responsive to conventional root canal treatment and may need additional surgical treatment. Patients with developmental defects of teeth must be treated according to its clinical and radiographic presentation for their optimum functional and esthetic outcome.

## Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms.

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## Conflicts of interest

There are no conflicts of interest.

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# Interdisciplinary management of diastema in maxillary anterior aesthetic zone with ceramic laminates – A case report

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## Abstract

An esthetic smile is considered to be an asset to an individual's personality. Any deviation from the natural appearance compromises the facial aesthetics and diastema is one of the common deviations. Diastema not only distorts the pleasing smile by accentuating the observer's attention on it but also, deviate their attention from the rest of the dental composition. An unesthetic smile may cause self-consciousness, low self-esteem and repeated attempts to conceal perceived dental defects. Diastema may also change the airflow between the teeth leading to phonetic problem. Diastema closure is one of the challenging tasks and the treatment for its correction of may include periodontal surgery, orthodontic corrections, restoratives such as direct or indirect composite, partial or full crowns or ceramic laminate veneers or a combination of several therapies. The presented case report describes the procedure for diastema closure in the maxillary anterior region with an interdisciplinary approach using periodontal and restorative treatments.

**Keywords:** Crown lengthening procedure, Laminates, Multidisciplinary approach, Spacing in teeth.

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## Introduction

In today's world of health awareness, every individual demands esthetic appearance. An esthetic smile is one of the factors which adds a positive impact to the subject's personality. Any deviation from the natural may compromise the facial aesthetics in the form of the spacing, Midline Diastema (MD), discoloration or the proclination etc. MD not only diverts observer's attention but also accentuate the their observation on the defect.[1]

MD psychologically affects the self-consciousness, causes low self-esteem and tends the patient to attempt to conceal the anatomical defect with lips. Diastema may also change the airflow between the teeth which results in difficulty in phonetics.[2] Various treatment modalities are available to correct the MD depending upon the dimensions of space, cause of spacing and occlusion etc. Sometimes, it may also require periodontal surgery or orthodontic correction.

Restorations such as direct or indirect composites, partial or full crowns or ceramic laminate veneers or combination of several modalities are available to correct the diastema.[3] This article presents a case report of diastema closure in maxillary incisors i.e. esthetic zone, using porcelain veneers with an interdisciplinary approach in which orthodontic therapy was not feasible. Superior aesthetics, biocompatibility, high strength, polishability and insolubility of ceramics are added advantages over the conventional composite esthetic restorations for correction of diastema.

## Case Report

A 21-years-old healthy female patient reported to the Department of Conservative Dentistry and Endodontics, Government Dental College and Hospital, Mumbai, with a chief complaint of spacing between her upper anterior teeth and visited the department for correction of the same to have an aesthetic smile. The patient also exhibited a high smile line. **[Figure 1A]** On examination, there was spacing between maxillary central incisors and high frenal attachment along with short clinical crowns **[Figure 1B].** For clinical evaluation, extraoral and intraoral photographs were taken and diagnostic casts were made.

Figure IA : Extra-oral photograph showing midline diastema.

Figure IB : Intraoral clinical photograph showing diastema in the maxillary anterior teeth.

The patient was referred to orthodontic consultation but unfortunately, orthodontic approach was not advised as the arch length was longer compared to the total width of the teeth. Also, all teeth were present in the arch and the patient was not willing to undergo any orthodontic treatment. Thus, esthetic rehabilitation of the patient using laminates was planned with indirect restoratives.

Considering the clinical examination and photographs and after consultation with the patient, it was decided that the diastema would be closed after correction of gingival disparity i.e. high frenum attachment and high gingival line. Porcelain laminates were opted as the treatment of choice, due to their natural esthetic appearance, ability to augment the length of incisors and longevity without constant maintenance.

After scaling and polishing, the patient was appointed for surgical crown lengthening and frenectomy due to high frenum attachment and short clinical crowns. Study mode was made and surgical stent was prepared for esthetic crown lengthening **[Figure IIA].** A surgical stent was prepared by marking the desired gingival contour on the study model. The margins of the stent simulated the gingival margin of the finish restoration. Local anesthesia was secured using 2% lignocaine with 1:200000 adrenaline. Gingivectomy was done with respect to teeth #13 to teeth #23 region after placement of the surgical stent using a no.15 surgical blade **[Figure IIB** and **IIC].** The periodontal flap was elevated with a periosteal elevator and maintaining the biologic width the required osseous reduction was done. Frenectomy was performed by giving two incisions one above the frenum and one below the frenum; followed by removal of a thick band of a frenum **[Figure II D].**

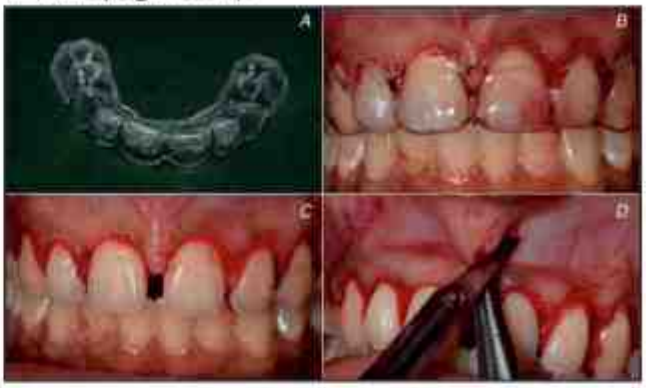


Figure IIA :Photograph showing surgical guide.
Figure IIB :Surgical guide in position to mark the gingival contour.
Figure IIC: Clinical photograph after crown lengthening procedure .
Figure IID :Clinical photograph showing frenectomy procedure.

The flap was approximated and sutured with 3-0 mersilk followed by covering it with periodontal pack (Coe-pak, GC, Europe). The patient was recalled after 7 days exhibiting satisfactory healing with no clinical symptoms. Clinically, adequate crown length was established with teeth #13 to teeth #23 region. The patient was recalled 15 days after the surgery for porcelain laminate preparation **[Figure III].**

Figure III: 2 weeks post surgical clinical photograph.

A mock-up restorative was prepared on the diagnostic cast and it was then transferred to the patient's mouth to evaluate the position of the final restoration. Three putty indices were made prior to tooth preparation for laminates. The teeth #11, #12, #21 and #22 were then prepared with the bevel type standard preparation for porcelain laminates. Preparation was done using 0.5 mm depth cutting bur and a chamfer bur. Proximal preparation was done up to palato-proximal line angle such that, the final restoration i.e. ceramic would cover the entire spacing. The buccal and the proximal preparation was done to 0.5mm with a chamfer finish line on the buccal surface and feather edge finish line

on palato-proximal line angle. To achieve desired translucency in the incisal edge area, 1mm of incisal preparation was also done. Preparation for tooth #22 was also modified to correct the rotation. A bevel type of incisal laminate preparation was followed on all the prepared teeth **[Figure IV]**.

Figure IV : Clinical photograph showing bevel type laminate preparation in teeth no. # 21, #22, #11 and #12.

Putty indices were used as a guide, in which one of the putty index was cut along the long axis of the prepared tooth; to examine the depth and amount of preparation required. Another index was cut horizontally to examine the overall laminate preparation **[Figure VA , VB]**.

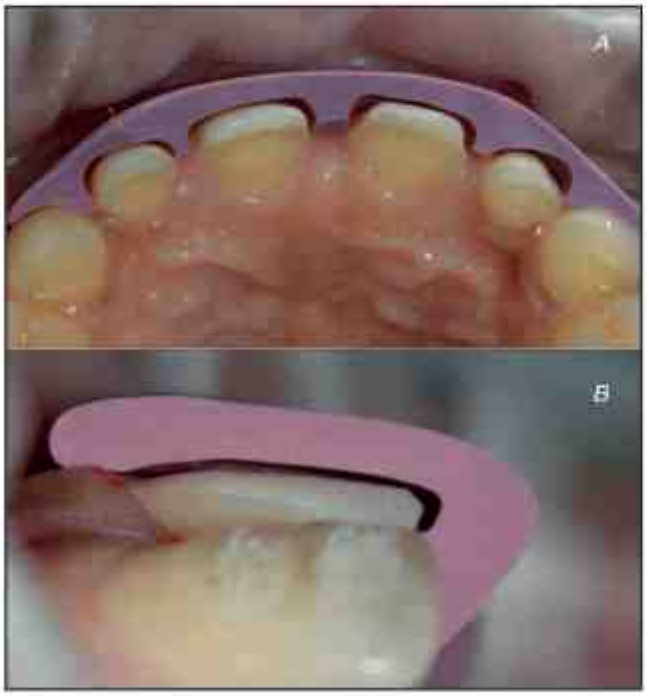


Figure VA : Occlusal view of customised putty index to visualise the tooth preparation.
Figure VB : Lateral view of customised putty index to visualise the tooth preparation.

After completion of the preparation, the gingival retraction cord (no.000) was placed and the impression was made using a two-stage impression technique with addition silicone material. Temporization was done using Luxatemp temporary crown material (DMG America LLC, Eaglewood) after spot etching and spot bonding the enamel surface.

Porcelain laminates were prepared by ultrasonic cleaning followed by etching the impression surface with 10% Hydrofluoric acid (HF). Tooth enamel surface was etched with 37% phosphoric acid followed by washing and drying. The dentin bonding agent was applied to the etched tooth surface. The silane-coupling agent was applied on the etched inner surface of the laminates without curing. Clear composite luting agent was then applied on the inner surface of laminates and the veneers were then placed on the tooth and cured. Curing was done first on the palatal side to reduce the polymerization shrinkage, followed by all other sides **(Figure VI A,B,C,D)**.


Figure VIA : Clinical photograph showing labial view after cementation of porcelain laminates.
Figure VIB: Clinical photograph showing occlusal view.
Figure VIC : Clinical photograph showing right lateral view.
Figure VI D: Clinical photograph showing left lateral view.

Six months follow up of the patient revealed intact porcelain laminates with desirable healthy tissue response. **(Figure VII)**.

Figure VII: Post operative extra-oral photograph after laminate cementation.

## Discussion

In today's world of health awareness every individual desires to be fit and healthy. Oral health being an integral part of the general health, it is considered as a mirror to a good health. A pleasing smile not only affects the individual

socially but also influences psychologically. Tooth as a prime element of the smile, is the most influential factor to determine the overall appearance of an individual. The colour, size, shape and position of the maxillary central incisors play a vital role in the dental esthetics of an individual.

In order to appear pleasing, the maxillary central incisors must be in proportion to the facial morphology and be consistent to the arch.[4] In dentistry the term "Golden proportion" is used which is a mathematical theorem concerning the proportions of the dentition.[4,5] According to this rule, if the width of each anterior tooth is approximately 60% of the size of its adjacent anterior tooth, then it is considered aesthetically pleasing.[6-9] It follows logically that if the width of the lateral incisor is 1, the central incisor should be 1.618 times wider and the canine should be 0.618 times narrower.

With the increasing demands for esthetic restorations, it becomes necessary to introduce new esthetic restorative materials, possessing the combination of the strength and esthetic qualities when used in the anterior esthetic zone. For restorative correction of MD, various treatment options are available such as; direct composite veneer, indirect composite veneer, laminates, full-crown restorations, or porcelain laminates etc. Among these, composites may show discoloration, marginal leakage or frequent breakdown. Thus, porcelain laminates opted as the choice of material because it possesses both the strength and the resistance along with its esthetic qualities desired in anterior region.[7-10] Porcelain Laminate Veneers (PLVs) have become the esthetic alternative to the ceramic or the traditional porcelain-fused-to-metal crowns. Porcelain laminates have several advantages like; it requires conservative preparation, has life-like appearance and excellent tissue response. On the other hand, the full crown preparation would have been more invasive and require removal of additional healthy tooth structure.

In the present case, esthetic rehabilitation of MD and rotation was done with porcelain laminates using a minimalistic approach. Due to the presence of short clinical crowns and high smile line crown-lengthening procedure was also employed keeping in mind the width of the attached gingiva. Dealing with MD, is also associated with soft tissue challenge, because the teeth being treated are "mesialized."[6] In this case, the labial frenum was thick, fibrous and its attachment was high thus, required frenectomy. The gingival zeniths of the teeth were also moved mesially using customised surgical guide to provide the correct axial inclination of the final restoration.

In this case, three putty indices were made; out of which two were used as guide to check the amount of tooth preparation and to keep it as minimalistic as possible whereas; the third index was used for temporization purpose. These customized putty indices were acted as a guide for conservative laminate preparation. Tooth #22 also has minor rotation, which was corrected by including it in laminate preparation.

## Conclusion

MD is a common dental malformation, which not only affects the facial aesthetics but also affects the individual socially and psychologically. Its correction is a matter of vital importance to the patient especially young adults which requires meticulous diagnosis, definite tooth preparation and sometimes surgical intervention. Porcelain veneers may be the choice of the treatment in the correction of MD due to their life-like appearance, strength and longevity.

## Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms.

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## Conflicts of interest

There are no conflicts of interest.

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# Non-surgical endodontic management of an apically separated instrument in the root canal of mandibular first premolar - A case report

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## Abstract

In routine endodontics, a clinician may encounter a procedural error at any stage during the treatment; which may alter the desired outcome. Instrument separation within the root canal is one of the most common errors during the root canal preparation. It often hinders the complete cleaning and shaping, thereby may result in treatment failure. Various approaches for the management of separated instrument have been described in the literature but; the treatment outcome is favorable only if proper cleaning of the canal could be performed. This article reports a successful retrieval of the separated instrument at the apex of mandibular first premolar using dental loupes and sonic endodontic activation.

**Keywords:** Bypass, Fractured instrument, Irrigation, Retrieval, Sonic activation.

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## Introduction

The success of the endodontic treatment depends on thorough cleaning and shaping and three-dimensional obturation of the root canal space. However, at times the desired outcome may not be achieved due to some unforeseen procedural error. One of the most commonly encountered procedural errors is the separation or the breakage of the endodontic instrument inside the root canal. The term broken or separated instrument may imply to the hand or rotary files, Gates Glidden drills, pesso drills, lentulospirals, thermo-mechanical gutta-percha compactor, tips of spreader or plugger etc. which breaks inside the pulp space.

Various factors are identified as a the cause of separation of endodontic files such as canal curvature, anatomic variations, practitioner experience, co-operation from the patient, frequency of instrument use, torque and speed of rotation of rotary files. Studies in literature reported that the separation rate of the Nickel-Titanium (NiTi) rotary instruments has been in the range between 1.3-10.0%, whereas the separation rate of Stainless Steel (SS) instruments ranges between 0.25-6%.[1-4] The separated instrument fragment may block the further apical access to it and thereby compromises the treatment outcome. Thus, to gain the access apical to the instrument; the removal of the fractured instrument or at least bypassing the fractured instrument becomes necessary for the complete debridement. In case when a patient is asymptomatic and these modalities have failed or not feasible; then the preparation and obturation of the accessible remaining part of the canal is advisable.[5,6]

Retrieval of the broken instrument is considered as one of the most challenging procedures requiring the highest skills and specialized armamentarium. The management of broken instrument at the coronal or the middle one-third of the canal is known to be easier as compared to those which have broken in apical one third. Limited access, moderate to severe curvature, narrow and tapering canal diameter, embedment of the broken instrument, chances of pushing it beyond the apex and possible vulnerability for lateral root perforation, makes the retrieval of apically broken instrument a more difficult task. Conversely, when the preparation of the root canal is completed and after that, if the instrument has broken; it may act as an alternative obturating material if its fit and seal achieved is proper. But, when it does not provide a good apical seal, it may allow the apical ingress

and cause the endodontic failure. Thus, proper case selection and careful attempts should be made for its retrieval in cases when it appears possible. This article presents a case where an apically broken instrument was bypassed and then retrieved using sonic endodontic instruments.

## Case Report

A 45 years old healthy female patient was referred by a private dental practitioner to the Department of Conservative Dentistry and Endodontics, Government Dental College and Hospital, Mumbai, for the management of broken rotary endodontic instrument in the mandibular left first premolar i.e. tooth #34. Clinically, the tooth #34 was tender to percussion. Intra Oral Peri Apical (IOPA) radiographic examination revealed the presence of a radiopaque object suggestive of a broken instrument in the root canal **[Figure I]**.

Figure I: IOPA of tooth # 34 showing separated instrument in the apical third of the root canal.

The tooth #34 appeared to have a single canal with 3 mm of a separated instrument at the apical third and the tip of the instrument was 1mm short of the radiographic apex. IOPA also showed the widening of the periodontal ligament space, loss of lamina dura and periapical rarefaction. The case was diagnosed as Symptomatic Apical Periodontitis (SAP) with fractured instrument in the apical third in the root canal of tooth #34.

After explaining the clinical situation along with the treatment options and prognosis to the patient; it was decided to bypass the instrument followed by an attempt for its retrieval. The patient's informed consent was obtained and local anesthesia was administered. Tooth #34 was isolated under a rubber dam and no. #10 K-file (Mani, Japan) was gently introduced into the canal where a hard stop was felt at 13 mm. Tooth length was estimated to 16mm from the preoperative IOPA. Using no. #6, no. #8, no. #10 K-files sequentially along with copious use of lubricants; the separated instrument was bypassed from 13 mm to 16 mm length in the root canal. After reaching the working length, a glide path (besides the broken instrument) was prepared by successively enlarging the canal using no. #10, no. #15 and no. #20 K-files. Then no. #20 H-file was used gently in pulling and rasping motion in an attempt to retrieve the bypassed instrument. Unfortunately, the retrieval attempts were failed. Considering the required preparation of the root canal, it was planned to prepare the canal with rotary NiTi instruments i.e. Protaper Gold files (Dentsply, Sirona). The insertion of every instrument in the canal was preceded and proceeded by copious irrigation using a negative pressure device PATS (Pro-Agitator Tip System, sonic activation). After canal preparation till the working length with F1, the broken instrument was felt loosed and came out to the orifice of the canal during negative pressure irrigation **[Figure II - IV]**.

Figure II: Post-instrument retrieval clinical photograph of tooth #34.

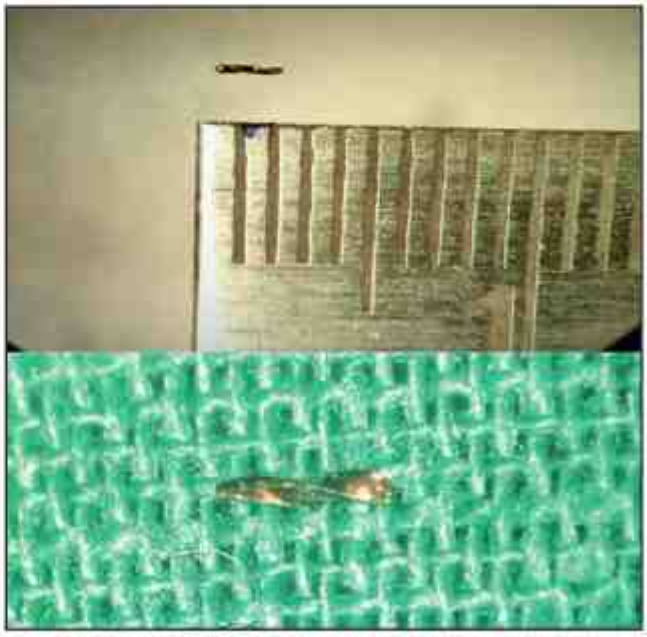

Figure III: Retrieved separated instrument (3mm).

Figure IV: Post-instrument retrieval IOPA of tooth #34.

The root canal was finally prepared using F3 finishing file. After confirming the apical tug back of the corresponding size master cone and after its radiographic verification, the obturation was done using AH plus sealer and thermoplaticized obturation technique followed by its post endodontic restoration **[Figure V- VII]**.

Figure V: Working length IOPA of tooth #34.

Figure VI: Master cone IOPA of tooth #34.

## Discussion

Success of the endodontic treatment depends on knowledge of root canal anatomy and its variations, proper access cavity preparation, thorough cleaning and shaping of the root canal and three-dimensional obturation of the canal.

Figure VII: Post obturation IOPA of tooth #34.

Shaping is considered as the most critical step in the root canal treatment; as improper cleaning may lead to harboring of microorganisms and endodontic failure.

During cleaning and shaping various endodontic instruments are inserted for intracanal usage. These instruments may break in the root canal at any stage during the canal preparation leading to the endodontic mishap. Various factors are responsible for the instrument breakage in the canal such as atypical root and canal anatomy, canal calcifications, improper usage or excessive use of the same instrument, etc. When such an instrument breaks in the canal, it may lead to inadequate preparation of the canal apical to it and may cause the failure. It may also have legal implication when its breakage has not been informed to the patient and the patient was not referred to the specialist in time.

During the preparation of the root canal, the instrument may break in the root canal or beyond the canal. The probability of its bypass or the retrieval depends on several factors such as its position in the canal, accessibility, size of the canal, size of the instrument broken and the remaining dentin thickness around the instrument etc. In case when an instrument breaks in the canal, then an initial attempt must be made to retrieve it and when it is not possible, at least try to bypass it. But, in an attempt to retrieve or bypass the instrument, excessive root dentin should not be removed as it may compromise the prognosis of the tooth. Similarly, when the instrument separates at the apical third after hand instrumentation and thorough cleaning-shaping; and when can not be retrieved it can be made as a part of obturation.

Separated instrument may alter the prognosis of the endodontic treatment in an indirect way when it obstructs the complete debridement of the root canal. In the present case, the radiograph showed a wide root canal having an instrument separation 1mm short of the apex, periapical rarefaction and persistent pain as complained by the patient. Thus, it was decided to gain the access to the area 1mm apical

to the separation so as to achieve complete cleaning. This can be achieved by either retrieval or bypassing a separated instrument.

Successful orthograde retrieval of the fractured instrument depends upon various factors like tooth factor (length, curvature etc.), equipment and instrument factor, clinician factor and patient factor.[4,6] Variety of instruments and techniques are available for instrument retrieval like Masserann kit, Ultrasonics, Gates-Glidden drills, Brasseler Endo extractor kit, Cancelliers, Wire loop technique, Mounce extractor and Tube technique etc. However, with all the available techniques of the retrieval of the separated instrument; excessive removal of root dentin coronal to the instrument is a major disadvantage.[7] Also, it may result in root perforation[8] or predispose the teeth to vertical root fracture.[9] Therefore, bypassing the separated instrument can be an appropriate treatment option with a good success rate.[10] In this case, instrument bypass was successfully completed up to no. # 20 K-file and it was decided to further enlarge this newly created glide path; as the diameter of the canal is the most significant factor in the removal of debris and for obtaining maximum results in root canal irrigation.[11] Root canal preparation using NiTi rotary should be done with utmost care and precaution; so as to prevent the separation of another file next to the already separated instrument. For complete chemico-mechanical preparation, copious irrigation along with instrumentation and sonic activation of irrigants was done. As in Endodontics, active irrigation plays an important role to initiate fluid hydrodynamics, that results in shear wall forces which cleans the canal surfaces.[12] All the efforts of bypassing the instrument and activated irrigation ultimately resulted in loosening of the broken file and it was retrieved without compromising much of the sound root dentin.

## Conclusion

Instrument separation is considered as an endodontic mishap and prevention of the instrument breakage is the best strategy to avoid any stress and anxiety associated with it. Straight-line access, glide path preparation, use of chelating agents like Ethylene Diamine Tetra Acetic Acid (EDTA), avoid forcing of the file, timely and vigilant discarding of instruments, etc. prevents the instrument separation. But, in case if mishap occurred, every attempt should be made to either bypass or retrieve the separated instrument utilizing the most conservative approach without jeopardizing the sound dentin and overall prognosis of the tooth.

## Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms.

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## Conflicts of interest

There are no conflicts of interest.

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