ENDODONTIC RETREATMENT: A CHANCE TO REWRITE HISTORY

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INTRODUCTION

Endodontics plays a significant role in raising the standard of oral health. With advances in the techniques and technology for cleaning, shaping, and obturating root canals, clinicians can successfully treat increasingly difficult cases. This new knowledge can also improve or correct earlier efforts. Endodontic retreatment is an opportunity to resolve problems with state-of-the- art solutions. In other words, we can rewrite history. Retreatment of previously obturated root canals is becoming more and more common in endodontic practice. Retreatment may offer the patient a second chance to save a root-treated tooth that would otherwise be destined for extraction (1).

Non-surgical retreatment is a procedure to remove previously placed obturation materials, correct reason for failure, clean/shape and reobturate (American Association of Endodontists). The initial stage of any retreatment procedure is the removal of previous root filling material to allow adequate cleaning, disinfection, and obturation of the root canal space.

The main goals of retreatment are regaining access to the apical foramen by complete removal of the root canal filling material thus facilitating sufficient cleaning and shaping of the complete root canal system and final obturation. Only if the filling material can be removed completely and the root canal negotiated to the apical foramen, thus allowing thorough debridement, can the prerequisites for successful retreatment be fulfilled. In these cases the success rates for retreatment ranges from about 65% (Molven 1974, Allen et al. 1989) to more than 80% (Strindberg 1956, Selden 1974, Sjögren et al 1990) (2)

REVIEW OF LITERATURE`

SL NO	AUTHOR	JOURNAL NAME AND YEAR	TYPE OF STUDY	MATERIALS AND METHODS	CONCLUSSION
1	Varawan Sae-lim et al, RajamanickamI, Lim BK, Lee HL	Effectiveness of ProFile .04 taper rotary instruments in endodontic retreatment. Journal of Endodontics February(2000)volume26;issue 2;pages 100-4	In vivo	Author investigated theretreatment effectiveness of 0.04 taper nickel-titanium rotary Profiles.Retreatment was done using Profilealone, Profile and chloroform and using hand fileswith chloroform.	It was concluded that Pro-file with or without chloroform seemed to be a viable alternative retreatment method.

2	J.J. Ferreira J. S. Rhodes & T. R. Pitt Ford	The efficacy of gutta-percha removal using profiles International journal of Endodontics December 2001 Volume 36, pages267-274	In vitro	Author compared theefficacy of gutta-percha removalfrom obturatedroot canals usingProfiles. Retreatment was performed with the following techniques: K-flexofiles withchloroform; Profile 0.04 taper alone. The time for eachmethod was measured. Amicrofocal macroradiographic technique wasused to evaluatethe amount ofdebris remainingwithin the root canals after theprocedure.	It was concluded fromthe studythat Pro-files orhand filewith chloroform produced similarly clean canals and Profiles were faster.

3.	J.Peterson & J.L Gutmann	The outcome ofendodontic resurgery: a systematic review. International Endodontic journal April(2001); volume34; issue3; pages 169-75	Rev iew	It was observedthat studies published between1970-1997, 330 patients out of 2375 (14%) underwent resurgery forfailure of healing as determinedradio graphically. Ofthis population35.7% healed successfully afterre-surgery, 26.3% healed with uncertainresults and 38% did not heal at the one-yearfollow up	They concluded that although there is nearly equal distribution of results between all categories a 35.7% rate of healingas. Assessed radio graphically is essentially equivalent to the 38%failure rate.

4.	BrianE. Bergero nDavid F. Murchi son, William G. Schindl er, and William A. Walker	Effect of Ultrasonic Vibration and Various Sealeran Cement Combinations on Titanium PostRemoval Journal of Endodontic(200 1) volume27; issue 1;pages 13-17	In vivo	This studydetermined theeffect of ultrasonic vibration on the force required to remove prefabricated posts. Posts cemented in teeth obturated with gutta-percha and AH26 sealerdemonstrated significantly greater resistanceto dislodgement, compared with teeth obturatedwith guttapercha and Roth's 801 elite sealer.	There was no statistical difference in retention off posts cemented with either zinc phosphate or panavia21, regardless of the sealer used. Additionally ultrasonic vibration increased post retention for both cements.
5.	L. V. Betti& C.M Bramante	Quantec SC rotary instruments versus hand files for gutta-percha removal in root canal retreatment. International endodontic journal October(2001);volume34;issue 7;pages 514-19	In vitro	Twentymaxillary central incisors with a single straight canal were selected. The Canals were instrumented and filled before the teeth were randomly divided into two groups of 10 specimens each. In group 1Quantec SC rotary instruments were used for	Though Quantec SC instruments took less time, hand instruments and solvent cleaned canals more effectively

				filling removal and in group 2, hand files and solvent. Thefollowing factors were evaluated: time taken to reach working length, time for gutta- percha removal, total time, apically extrudedmaterial duringfilling removaland number of fractured instruments. Radiographs were taken and the teeth weregrooved longitudinally and split. Thecanal walls ofeach half and the radiographs wereevaluated visually forcleanliness. Theywere thendigitized using ascanner and the residual debrisassessed. The analysis wascarried out in the cervical, middleand apical thirds separately as well for the whole canal.	
6.	A.Gesi S. Magnolfi, , C. Goracci, , MS, and M. Ferrari	Comparison of Two Techniques for Removing Fiber Posts Journal of Endodontics; September (2003) volume29;issue 9;pages 580-582	In vitro	Sixty extracted anterior teeth were treated endodontically. A post space with a standard depth of 10 mm was	. For the bur kits, the procedure involving the use of a diamond and a Largo bur was significantly faster

				prepared in each root canal. The sample was randomly divided into3 groups of 20 specimens each. Three different types of posts were cemented: group 1, Conic 6% tapered fiber posts (Ghimas); group 2, FRC Poster fiber posts (Ivoclar-Vivadent); and group 3, Composipost carbon fiber posts (RTD). To remove the post, for half of each group's specimens the burs from the RTD fiber posts removal kit were used (subgroup A). From the other half of the teeth in each group (subgroup B), posts were removed by using a diamond bur and a Largobur.	
7.	Marcela Fridland and Rafael Rosando	Mineral Trioxide Aggregate (MTA) Solubility and Porosity with Different Water- to-Powder Ratios Journal of Endodontics December (2003),volume29:issue12:pages- 814-817	In vitro		This study tested mineral trioxide aggregate (MTA) solubility and porosity with different water-to-powder

					proportions. This also determined the chemical composition of the salts dissolved by MTA. It was determined that the degree of solubility and porosity increased as the water to powder ratio increased. The chemical analyses of the salts dissolved by MTA in the water identified the presence of calcium as the main chemical compound. The pH level of the solution was highly alkaline, ranging between 11.94 and 11.99

8.	M.Hulsmann& V. Bluhm	Efficacy, cleaning ability and safety of different rotary NiTi instruments in root canal retreatment. International Endodontic journal July(2004);volume37;issue7:pag es 468-76	In vitro	Eighty extracted single-rooted anterior teeth were enlarged to size 35 and obturated with laterally condensed gutta- perchausing AHPlus as the sealer. Removal ofgutta-percha was performed with the following devicesand techniques: Flex Master, GT Rotary, Pro Taper and Hedström files. All techniques were used with and without the solvent eucalyptol. The following data were recorded: time taken to reach the calculated working length and time required for the removal of gutta- percha. The teeth were split longitudinally and photographed. Cleanliness of the root canal walls was scored using the projected slides with a total magnification of approximately 70x. Statistical analysis was performed using the two-way anova (P < 0.001) for the analysis	Under the experimental conditions, Flex Master and ProTaperNiTi instruments proved to be efficient and time-saving devices for the removal of gutta- percha. The use of eucalyptol as a solvent shortened the time to reach the working length and to remove the gutta-percha, but this was not significant.

				of working time.	
9.	Angela Delfina,Bittencout Garrido	Influence of Ultrasound, With and Without Water	In vitro	This study evaluated the amount of force necessary to dislodgedposts cemented with resin zinc phosphate cement with the help of ultrasound, with or without water- spray. Instron testing machine was used ultrasound with water spray significantly reduced the forces necessary to displace posts cemented with Panavia F; however this value was similar to the efficacy of ultrasound with water spray with posts cemented with Zinc phosphate.	Thus it was concluded that coolingwith ultrasound interferes with the forces necessary for post removal, depending on the type of cement used.
10.	Matwhew Lindemann	Comparison of the Efficiency and Effectiveness of Various Techniques for Removal of Fiber Posts Journal of Endodontics July (2005);volume 31,;issues 7,pages 520-522	In vitro	A study was conducted to determine the efficiency and effectiveness of several techniques for fiber post removal. Four groups of 20 mandibular premolars were endodontically treated and	The results suggested that removal kits were significantly more efficient, while diamonds and ultrasonics were more effective. Removal kits could

				obturated. Post spaces were prepared for the following post systems: ParaPost XH, Para Post Fiber White, Luscent Anchors, and Aestheti Plus After cementation, 10 posts of each group were removed with their corresponding manufacturer's removal kit and the other 10 removed with diamond burs and ultrasonics. Removal times were recorded and the teeth were sectioned verticallyand microscopically analysed for removal effectiveness based on a 0 to 5 point scale. Removal kits removed Luscent Anchors the fastest (mean =3.9 min) and most effectively (mean = 2.6), while Aesthetic- Plus posts were removed the slowest (mean =7.3 min) and least effectively (mean =3.4). Diamonds and ultrasonic required an average of 10 additional minutes for each fiber post system removal, yet removal effectiveness improved half a point.	be enhanced with subsequent ultrasonic instrumentation to remove remaining fibers and cement.

11.	John T.Dominici, Clark S, Scheetz J, Eleazer PD	Analysis of Heat Generation Using Ultrasonic Vibration for Post Removal Journal of Endodontics April (2005);volume 31;issue 4;pages301-303	In vitro	This study measured the temperature of the root surface and post during the application of ultrasonic vibration to cemented posts to simulate post removal procedure. Root canal therapy was performed on ten extracted maxillary incisors. A stainless steel Parapost was cementet into each prepared post space. Ultrasonic vibration was applied to the post and temperatures were recorded at the coronal post and the cervical root surface. Data were analysed with ANOVA using the independent variables of (a) time of ultrasonic application (15, 30, 45 and 60 s) and 2) location (post and root surface).	They concluded that Ultrasonic application to the post for longer than 15 s generates high temperature on the root surface.

12.	J.C Budd	Temperature rise of the post and on the root surface during ultrasonic post removal International endodontic journal May(2005);volu me38,pages 705–711	In vitro	Two ultrasonic devices, one piezoelectrical (Pi) and one magnetostrictive (Ma), were investigated. Temperature rise was measured at 30, 60, 90 and 120 s intervals using calibrated infrared thermography (n¼ 80). Temperatures were recorded at 45 ms intervals.	There were significant differences in temperature rise as a function of ultrasonic device, location on the tooth and cooling methodutilized for post removal.
13.	M.M Gagliani, F. G. M. Gorni & L. Strohmen ger	Periapical resurgery versus periapical surgery: a 5-year longitudinal comparison International Endodontic journal (2005);volume 38;pages 320–327	In vivo	This study Monitored and compared the outcome of periradicular surgery in teeth that had previously undergone surgical retreatment versus teeth that were undergoing a surgical procedure for the first time. They used ultrasonic retro tips to prepare the apical root end cavity, and a zinc oxide EBA reinforced material was used to fill the apical root-end cavities. Lesions were radiologically examined from 1to 5 years following the surgical procedure. Radiographs were independently analysed,	They concluded that surgical retreatment of teeth previously treated with surgery is a valid alternative to extraction. However, association with post- treatment disease was greater than after a primary surgical approach.

				according to a previously published classification.	
14.	A.V. Masiero& F.B. Barietta	Effectiveness of different techniques for removing gutta- percha during retreatment. International Endodontic journal January(2005) ;volume38;issue 1;pages 2-7	In vitro	Eighty extracted mandibular premolar teeth were selected for thestudy. The teeth were root filled using thermomechanical compaction of gutta-percha. After 8 months, the filling material wa removed and Canals were reinstrumented using the following techniques: group I - hand instrumentation with K-type files (SybronEndo, Orange, CA, USA); group II - K3 Endo System (SybronEndo); group III - M4 system (SybronEndo) with K-type files (SybronEndo); and group IV - Endo-gripper system (Moyco Union Broach, York, PA, USA) with K-type files (SybronEndo). The amount of filling debris remaining on root canal walls was assessed radiographically; the images	In the apical third, K3 rotary instruments were more efficient in removing gutta-percha filling material than the other techniques, which were equally effective for the other thirds.

				were digitized and analysed using AutoCAD 2000 software. Total canal area, area of the cervical, middleand apical thirds, and area of remaining filling material were outlined by one operator. The ratios between these areas were calculate as percentages of remaining debris. Thereafter, data were analysed by means of one- way anova and the post-hoc Duncan test to identify differences between the four techniques.	
15.	B.Suter	Probability of removing fractured instruments from root canals. International Endodontic journal February(2005); volume38;issue2 :pages 112-23	In vivo	Within an 18- month period all referred endodontic cases involving fractured instruments Within root canals were analysed.The protocol for removal of fractured instruments was: create straight- line access to the coronal portion of the fractured instrument, attempt to create a ditched groove around the coronal aspect of the instrument using ultrasonic	Curved canals are a higher risk for instrument fracture than straight canals. In curved canals rotary instruments(including lentulo spirals) fractured more often than other instruments. In all, 87% of the fractured instruments were removed successfully. A decrease in success

				files and/or to bypass it with K- Files. Subsequently, the fractured instrument was vibrated ultrasonically and flushed out of the root canal or an attempt was made to remove the instrument with the Tube- and-Hedström file-Metho or similar techniques. The location of the fractured instrument and the time required for removal were recorded. Successful removal was defined as complete removal from the root canal without creating a clinically detectable perforation.	rate was evident with increasing treatment time. The use of an operating microscope was a prerequisite for the techniques used to remove the fractured instruments
16.	De Oliveira DP, Barbizam JV, Trope M, Teixeira FB	Comparison Between Gutta- Percha and Resilon Removal Using Two Different Techniques in Endodontic Retreatment Journal of endodontics April(2006);volume3 2;issue4;pages 362-364	In vitro	Compared the remaining filling material and working time when removing gutta-percha/AH 26 and Resilon/ Epiphan y from root filled extracted teeth. The root fillings were removed using chloroform and two different rotary systems (K3 and Liberator files). The amount of residual filling material on the canal walls was imaged and	In the groups filled with Resilon/Epiphany , the filling was removed faster than groups filled with gutta- percha/AH 26. K3 rotary system was faster than Liberator to remove both gutta-percha and Resilon. Resilon/ Epiphany was effectively removed with K3 or

				measured using image analyzer software. The group filled with Resilon/Epiphan y and retreated with K3 files demonstrated the least residual filling material on the walls.	Liberator rotary files.
17.	Andrew s. Huttulaet	The Effect of Ultrasonic Post Instrumentation on Root Surface Temperature Journal of endodontics November 32;issue 11,pages 1085-1087 (2006)	In vitro	Measured root surface temperature changes when ultrasonic vibration, with and with out irrigation, was applied to cemented endodontic posts. Twenty- six, extracted, single-rooted premolars were randomly divided into two groups. Root lengths were standardized, canals instrumented, obturated, and posts cemented into prepared spaces. Thermocouples were positioned at two locations on the proximal root surfaces. Root surface temperatures were significantly higher when posts were instrumented dry.	Irrigation during post removal with ultrasonics had a significant impact on the temperature measured at the external root surface.
18.	Sonali neja, Manju kumari	Effect of internal matrices of hydroxyapatite and calcium sulfate on the sealing ability of mineral trioxide aggregate and light cured glass ionomer	In Vitro	The study was conducted on 70 human molars. Sixty teeth with furcal perforations were randomly divided into six	MTA showed the best sealing

		cement Journal of conservative dentistry January-March(2011);vo lume14;issue1:p ages 6-9		groups of 10 teeth each and repaired with MTA or LC GIC either alone or over an internal matrix, i.e., CS or HA. Access openings were filled with composite resin. Five teeth with unrepaired perforations were used as positive controls and five teeth without perforations were used as negative controls. The teeth were immersed in a solution of 2% methylene blue dye for 2 weeks. The samples Were then sectioned and evaluated for linear dye leakage and analyzed statistically.	ability followed by LC GIC, MTA + CS, MTA + HA, LC GIC + CS and LC GIC + HA.
19.	David Keinan, Joshua Moshon ov,Ami Smidt,	Is endodontic re-treatment mandatory for every relativelyold temporaryrestoration?	Revie w	The authorsexamine whether there is anydecisive evidence to support the revision of root	In a review of the literature, the authors found noclear evidence tosupport immediate replacement of
		The journal of American Dental		fillings that have been exposed to	well-obturated endodontic

		Association April 2011, volume142, issue 4,pages391-396		the oral environment for more than three leakage by using different tracers and techniques. The need to achieve a tight, permanent coronal seal as soon as possible after the completion of endodontic treatment is obvious. However, the clinical importance of micro leakage studies recently has been questioned because of their wide range and even contradictory results, and findings from only a few clinical investigations have demonstrated a clear relationship between the months, undertaken solely because ofsuspicion ofmicro leakage.Researchers innumerous endodontic studies have addressed the evaluation of coronal micro endodontic success rate and failure rate owed to coronal micro leakage in cases involving high- quality endodontic therapy.	treatment that has lasted more than Three months solely because of suspicions of micro leakage. It may be prudent insuch cases to make a new coronal restoration immediately and to observe the tooth for at least three months

20.	Ashu Sharma, G R. Rahul, Soorya T. Poduval, and Karu nakar Shetty	Removal of failed crown and bridge Journal of clinical and experimental Dentistry July(2012);volu me 4;issue3: pages167–172	Review	Crown and bridge have life span of many years but they fail for a numberof reasons. Over the years, manydevices have been designed to remove crowns and bridges from abutment teeth. While the removal of temporary crowns andbridges is usually very straight forward, the removal of a definitive cast Crown with unknown cement is more challenging. Removal is often by destructive means. There are a number of circumstances, however,in which conservative	The article emphasized on general issues and concepts in crown and bridge disassembly. Success lies in careful treatment planning; there will be situationswhere conservative approach is advantageous andsituations wheresuch attempts are contraindicated. None of the systems mentioned here are universally applicable. Therefore, it is important to adopt a flexible approach, that is, when you fail in removing crown

				disassembly would aid the practitioner in completing restorative/endodontic procedures. There are different mechanisms available to remove a failed crown or bridge. But there is no information published about the classification of available systems for crown and bridge removal. So it is logical to Classify these systems into different groups which can help a clinician in Choosing a particular type of system	and bridge by using one system then other systems should be tried. It is also very important to make risk-benefit analysis when considering conservative or semi conservative disassembly and inform the patient of those risks.

				depending upon the clinical situation. The aim of this article is to provide a classification for various crown And bridge removal systems; describe how a number of systems work; and when and why they might be used.	
21.	Michael Solomonov	Self-Adjusting Files in Retreatment: A High-resolution Micro–Computed Tomography Study journal of Endodontics September 2012, volume 38, issue 9., pages 1283-1287	In vitro	Twenty-eight mandibular molar teeth with oval distal root canals were divided into 2 equal groups of 14teeth each. The distal root canals were instrumented with protaper files upto an F2 instrument with roots were	None of the retreatment methods rendered all of the canals completely free of all root filling residue. Under the conditions of this study, the ProFile was SAF procedure was more effective than the Protaper Procedure and the

				subsequently filled and the root filling were perform,ed with D1- D3 protaper retreatment files followed by F1 and F2 ProTaper instruments or with a #25 .06 ProFile followed by SAFs. Chloroform was used in both groups to assist in the removal of the root filling material. High-resolution micro-CT scans were used to measure th residual quantities of the root filling material after completion of the procedures.	left significantly less root filling residue in the root canal.

22.	F.Basmaci	Ex vivo Evaluation of various instrumentation techniques and irrigants in reducing E. faecalis within root canals. Interenational endodontic journal September(2013);volume46;issu e 9:pages 823-30	Ex vivo	To evaluate the effectiveness of single-file instrumentation techniques compared with serial Ni-Ti rotary instrumentation with several irrigation regimens in reducing E. faecalis within root canals.	No significant differences in terms of reduction in microbial counts were observed between single-file techniques (SAF and Reciproc) and serial Ni-Ti instrumentation technique (ProTaper) in combination with irrigants.
23.	A.S.Zuolo	Efficacy of reciprocating and rotary techniques for removing filling material during root canal retreatment. International endodontic journal October(2013);v olume46;issue10 :pages 947-53	In vitro	This study compare the efficacy of reciprocating and rotary techniques with that of hand files for removing gutta- percha and sealer from root canals.	It was concluded that endodontic filling material was observed on the canal walls of all teeth regardless of the technique used. Hand files combined with Gates-Glidden burs (group I) and the reciprocating technique (group III) removed More filling

					material from the canal walls than the Mtwo R files. The reciprocating technique was the most rapid method for removing gutta- percha and sealer, followed by therotary technique and the hand file technique.
24.	KavithaJanardanan	Coronal disassembly systems and techniques: An overview Year : 2014,Volume : 4,Issue : 1,Page : 33-40	Review	This study creates general awareness among the clinicians regarding the appropriate choice of crown removal systems and techniques in various clinical situations. Fixed prosthodontic treatment is often faced with complications involving failure of restoration or of	The successful use of any coronal disassembly device thereby depends on the judicious selection of the instrument or technique. Ensuring an ideal preparation taper and parallel path of insertion, using luting agent in the correct consistency, application of the

				the abutment due to improper treatment planning. In such situations, further management can be accomplished either byremoval and replacement or repair of the restoration. Removal of the crown and bridges for refabrication is extremely tedious and can lead to unpredictable consequences if proper technique is not used. An external device is always required for the removal of the failed restorations. Decrowning devices are a boon to dentistry to deal with such situations.	luting agent on the inner axial surface of the crown rather than on the entire intaglio surface and proper maintenance and sterilization of the instrument are the duties to be perfected by the clinician for an effective crow n removal.

25.	Swetha Kasam, Mariswamy AB	Efficacy of Different Methods for Removing Root Canal Filling Material in Retreatment - An In-vitro Stud Journal of Clinical and diagnostic research June(2016);volume10;issue 6;pages 06-10	In vitro	This study aimed to evaluate and compare the effective removal of guttapercha and sealer, amount of apical debris extrusion and time required for guttapercha removal using various endodontic files.	All techniques retained guttapercha/seale r remnants within the root canal. The ultrasonic retreatment tip proved to be an efficient method of removing obturated material. It was fastest with least apical debris extrusion.
26.	Mohammad Asnaashari, Hengameh Ashraf, Amir Houshang Daghayeghi, Seyed Masoud Mojahedi, and Saranaz Azari-Marhabi	Management of Post Endodontic Retreatment Pain With Low Level Laser Therapy Journal of lasers in medical sciences 2017 Summer; volume8;issue 3:pages 128–131	In vivo	The present study aimed to evaluate the effects of low level laser therapy (LLLT) on the reduction of pain after root canal retreatment.	Low level laser irradiation had limited effects to decrease pain associated with the endodontic retreatments in the first and second molars; however, more studies are required to assess the effects of differentparameter s of low level laser

					in this regard.
27.	Salwa Omar Bajunaid	Review of techniques for the intact removal of a permanently cemented restoration. Journal of General Dentistry March (2017); pages 48-53	Review	The aim of this article is to present the results of a systematic, content-based analysis of the literature on conservative and semi-conservative techniques for the intact removal of permanently cemented restorations and to discuss the advantages and disadvantages of each technique.	The safest and least traumatic means of Removing a cemented crown is to destroy it by cutting a slot and prying it out, thereby avoiding procedures that could harm the underlying tooth.

28.	Sidhartha Sharma, Vijay Kumar, Ajay Logani	Management of long-standing perforation with mineral trioxide aggregate using metronidazole-containing collagen as an internal matrix. Saudi Endodontic Journal August (2017);volume7 issue 2 ;pages 123-127	Case reports	The time elapsed from the development of the perforation is a critical factor influencing the posttreatment prognosis. Long-standing perforations usually show a worse prognosis than fresh perforations. Mineral trioxide aggregate (MTA) is widely used to seal perforations because of its biocompatibility and sealing ability in the presence of blood and moisture. Metrogene sponge isa metronidazole-containing absorbable collagen having significant	MTA with metrogene sponges as matrix provides an effective seal of root perforations and clinical healing of the surrounding periodontal tissue.

				antibacterial activities. It can be an added advantage when used as an internal matrix for long-standing perforation repair.	
29.	Haripriya Subbaiyan	Perforation Repair Using Absorbable Collagen Sponge and Biodentine. Journal of Clinical and Diagnostic Research. September(2018), ;Volume12;iss ue 9:pages ZD01-ZD02	Case report	The purpose of this case report was to describe the treatment of subcrestal perforation using absorbable collagen sponge as an internal matrix and biodentin to seal the perforation site	The purpose of this article is to present a case report in which absorbable collagen sponge was used as an internal matrix, and biodentine was used to seal the perforation. Immediate repair with good repair material and trying to be less invasive as possible ensures successful outcome despite complexity of the condition.

30.	Sarah Salloum, Hasan Al Houseini, Sanaa Bassam, Valerie Batrouni	Endodontic retreatment v/s implant Journal of Dental Health Oral Disorders & Therapy June (2018);Volume 9 issue 3;pages 245-248	Review	In this article they referred to the endodontic retreatment v/s implant referred to the comparison of the endodontic retreatment's outcome with That of the implant treatment's taking into account the patient's best interest. With the advent of new endodontic technologies and the struggling of implant innovations to achieve andmaintain high search results racking. Data Analysis areFacing more difficulties when performing	Accordingly, this literature review aims to answer one of the principal questions addresses by risk-benefit analysis of two long term treatments, that is "how safe, is safe enough?"

				meaningful cross-study comparisons.	
31.	Jitendra Lohar, Himanshu Sood, Pratikgiri Gosai, and Tariq M. Shekh	3P's in Retreatment Endodontic— An Often Forgotten Virtue Journal of Pharmacy and Bio-allied sciences February(2019); volume 11(Suppl 1):pages S76– S80	Case reports	This article presents four cases requiring removal of separated instruments from the root canal. All four cases were successfully treated by conservative means of instrument retrieval by using two different techniques.	Thus it may be concluded that the three P's, that is, □ Patience □ Persistence □ Perseverance When incorporated judiciously along with the conservative techniques for the retrieval of fractured instruments not only give us the desired results but also save precious residual radicular

					dentin.
32.	Mona Devi, Pardeep Mahajan, Shikha Baghi Bhandari, Prashant Monga, Nitika Bajaj, Fatinderjeet Singh	Comparative evaluation of removal of gutta-percha from root canals with laser using different solvents: An in vitro study Journal of endodontology Year : 2019 ,Volume : 31,Issue : 1,Page : 51-56	In vitro	The aim of this study is to evaluate the gutta-percha removal from root canals with diode laser using chloroform and Endosolv E solvents	The present study revealed that the diode laser with solvents (Chloroform and Endosolv E) were significantly more effective than only diode laser group in removing gutta-percha during retreatment of the root canal system. Out of these, Group 2 (diode laser along with chloroform as solvent) was more effective than other groups.

AIM OF RETREATMENT

The Patient Viewpoint

A patient may consider success as relief from acute symptoms, perhaps the resolution of swelling or absence of tenderness.

The Clinical Viewpoint

Success has traditionally been determined by lack of any symptoms and a normal radiological presentation, while any visible or radiological signs of disease indicate failure. It was the research published by Strindberg in 1956 that incorporated a system of criteria for assessment of success and failure based on the presence or absence of periapical rarefaction. Strindberg considered that the presence of periapical radiolucency after a period of 4 years following root canal treatment would indicate signs of biological failure.

CRITERIA FOR SUCCESS AND FAILURES

Strindberg criteria for success and failure:

	Radiographic findings
Success	The contours‟ width and structure of the periodontal margin were normal. The periodontal contours were widened mainly around and existing filling.
Uncertain	Technically unsatisfactory or ambiguous control radiographs that for some reason could not be repeated. The tooth was extracted prior to 3year follow
Failure	A decrease in the size of periapical rarefaction an unchanged periradicular rarefaction. An appearance of a new rarefaction or increase in previous rarefaction

The Histological Viewpoint

Histological assessment of an endodontically treated tooth may offer the ultimate standard for determining success or failure. However, this method is not very feasible and ethical.

Clinical Guidelines of the European Society of Endodontics

The European Society of Endodontics Guidelines indicate that root-filled teeth should be reviewed radiographically at 1 year and then subsequently as required for up to 4 years to assess whether treatment has been successful. Success would be indicated by relief from symptoms, healing of sinus tracts and reduction or complete resolution of periapical radiolucency.

If a root-filled tooth is functional, clinically symptomless and has no evidence of disease radiographically, then treatment can be considered a success.

SUCCESS GUIDELINES

Success

Clinical - There is no tenderness to palpation or percussion.

Normal mobility and function.

No sinus tract or periodontal defect. No signs of inflammation.
No pain or discomfort.

Radiological- Contours, width and structure of periodontal ligament space are normal.

The periodontal ligament contours are widened around excess filling material.

Mixed

Clinical - Sporadic or vague symptoms that are most often not reproducible.

Feeling of pressure or tightness.

Slight discomfort when chewing or pressing on tooth with finger or tongue. Radiological - The periapical area has not changed in size.
The periodontal ligament space does not look completely normal.

Failure

Clinical- Persistent symptoms.

Recurrent sinus tract swelling or pain.

Pain on percussion or palpation. Mobility or function that is not normal.

Radiological- The periapical area has not changed in size or has enlarged.

The appearance of new periapical or lateral radiolucency.
Maximum review time 4 years.

DISCUSSION

REASONS OF SUCCESS AND FAILURES

Failure can be defined as the lack of success.

The success of endodontics is of interest to dental professionals, patients, and third-party payers (37). Reported success rates for conventional endodontic therapy range from 40% to 97% depending on differences in patient selection, experimental design, clinical procedures, criteria for evaluation, and length of postoperative observation. This variation in success rate is in part due to the lack of a clear definition of the success and failure of endodontic treatment (43). Although some studies have used tooth retention and the absence of clinical signs and symptoms to define success, most studies have evaluated recall radiographs to determine endodontic success (1).

Endodontically treated teeth have a high rate of survival, especially when treated by specialists. This survival rate is as high or better than the survival rate reported for dental implants (44).

Reasons for Root canal treated tooth extractions have included periodontal disease, caries, coronal and root fractures, prosthetic complications, and endodontic failures (43).

The major factors associated with endodontic failure are the persistence of microbial infection in the root canal system and/or the periradicular area (45).

Other factors that may contribute to a persistent periradicular infection after root canal treatment include intraradicular infection, extraradicular infection, foreign body reaction, and cysts containing cholesterol crystals (46).

Procedural accidents like broken instruments, perforations, overfilling's, underfillings, ledges etc often impede or makes it impossible to accomplish appropriate intracanal procedures. Thus, there is potential for failure of root canal treatment when a procedural accident occurs during the treatment of infected teeth. Errors such as missed canals may also lead to root canal failure.

According to Nair et al, causes of endodontic failure in well treated teeth comprises (45).

Microbial factors

a. Intraradicular infection

b. Extraradicular infection

1. Microbial involvement in special situations

a. Overfilling

b. Coronal sealing

2. Nonmicrobial Factors

According to Donald et al, causes of endodontic treatment failure are divided into (47):

1. Prosthetic failures

a. Crown fractures

b. Root fractures

c. Traumatic fractures

d. Pathological restoration logical restoration

2. Periodontal failures

3. Endodontic Failures

a. Vertical root failures

b. Instrumentation failures

c. Resorption

MICROBIAL FACTORS

Intra radicular Infection

Environmental influences operate in the root canal system during treatment, allowing certain microorganisms to survive and, depending on several factors, induce failure. Such influences are affected by intracanal disinfection measures (chemomechanical preparation and intracanal medication) and the low availability of nutrients within a well-treated root canal. To survive in the root-filled canal, microorganisms must withstand intracanal disinfecting measures and adapt to an environment in which there are few available nutrients. Therefore, the few microbial species that have such ability may be involved in the failure of root canal treatment. If the root canal filling fails to provide a complete seal, seepage of tissue fluids can provide substrate for bacterial growth. If growing bacteria reach a significant number and gain access to the periradicular lesion, they can continue to inflame the periradicular tissues. The chances of a favourable outcome with root canal treatment are significantly higher if infection is eradicated effectively before the root canal system is obturated. However, if microorganisms persist in the root canal at the time of root filling or if they penetrate into the canal after filling, there is a higher risk that the treatment will fail (45). How high the risk of reinfection will be is dependent on the quality of the root filling and the coronal seal (12).

In most cases, failure of endodontic treatment is a result of microorganisms persisting in the apical portion of the root canal system, even in well-treated teeth. A radiograph of a seemingly well-treated root canal does not necessarily ensure the complete cleanliness and/or filling of the root canal system. To survive in the root-filled canal, microorganisms must withstand intracanal disinfecting measures and adapt to an environment in which there are few available nutrients.

Bacteria located in areas such as isthmuses, ramifications, deltas, irregularities and dentinal tubules may sometimes be unaffected by endodontic disinfection procedures. If the root canal filling fails to provide a complete seal, seepage of tissue fluids can provide substrate for bacterial growth. If growing bacteria reach a significant number and gain access to the periradicular lesion, they can continue to inflame the periradicular tissues. The microbiota associated with failed cases differs markedly from that reported in untreated teeth (primary root canal infection). Whereas the latter is typically a mixed infection, in which gram- negative anaerobic rods are dominant, the former is usually composed of one or a few bacterial species, generally gram-positive bacteria, with no apparent predominance of facultatives or anaerobes (45).

Commonly recovered microorganisms from failed root canals are Enterococcus faecalis, Streptococcus anginosus, Peptostreptococcus micros, Actinomyces israelii, Bacteroides graciIis, Candida albicans. The common recovery of E. faecalis from the root canals of teeth in which the previous treatment has failed is notable (16).

Enterococci are gram positive cocci that can occur singly, in pairs, or as short chains. They are facultative anaerobes, possessing the ability to grow in the presence or absence of oxygen 46. They are not favored by the conditions in the untreated canal, and when present they usually make up a very small proportion of the initial flora in the root canal. E. faecalis appears to be highly resistant to the medicaments used during treatment and is one of the few microorganisms that has been shown in vitro to resist the antibacterial effect of calcium hydroxide.

Enterococci have also been shown to have an ability to survive in root canals as single organisms without the support of other bacteria. A higher proportion of E. faecalis in teeth whose canals lacked an adequate seal has been noticed. E. faecalis usually enters the canal during treatment (16). Enterococci survive very harsh environments including extreme alkaline pH (9.6) and salt concentrations. They resist bile salts, detergents, heavy metals, ethanol, azide, and desiccation. They can grow in the range of 10 to 45°C and survive a temperature of 60°C for 30 min.

E. faecalis possesses certain virulence factors including lytic enzymes, cytolysin, aggregation substance, pheromones, and lipoteichoic acid (45). It has been shown to adhere to host cells, express proteins that allow it to compete with other bacterial cells, and alter host responses. E. faecalis is able to suppress the action of lymphocytes, potentially contributing to endodontic failure (46). When E. faecalis is present in low numbers initially, it can usually be eliminated; however, once established in the root canal system it is a difficult organism to eradicate. Another microorganism, Candida albicans, has also been observed in some previously root-filled teeth. Although fungi have occasionally been reported in untreated cases, they have been found in cases in which treatment had been protracted, and they have been associated with endodontic failures. Like bacteria of the species E. faecalis, these microorganisms appear to have an ability to utilize opportunities created by the removal of othemicrobes and also to have the capacity to grow in the low-nutrient environment of the treated canal (16).

Extraradicular Infection

The development of periradicular lesions creates a barrier within the body to prevent further spread of microorganisms. Bone tissue is resorbed and substituted by a granulomatous tissue containing defence elements, such as cells (phagocytes) and molecules (antibodies and complement molecules). A dense wall composed of polymorphonuclear leucocytes, or less frequently an epithelial plug, is usually present at the apical foramen, blocking the egress of microorganisms into the periradicular tissues. Very few endodontopathogens can advance through such barriers. However, microbial products can diffuse through these defence barriers and are able to induce or perpetuate periradicular pathosis Microorganisms established in the periradicular tissues are inaccessible to endodontic disinfection procedures, they can escape from the action of defence cells and molecules by defending themselves against the action of the complement system, avoiding destruction by phagocytes, causing immunosuppression, changing antigenic coats, and inducing proteolysis of antibody molecules. Thus, extraradicular infection may be a factor in the failure of endodontic therapy 45. Some oral microorganisms, such as Actinomyces spp. and Propionibacterium propionicum, may be implicated in extraradicular infections.

Probably, one of the most significant mechanisms of evasion from the host defence system is the microbial arrangement in a biofilm. A biofilm can be defined as a microbial population attached to an organic or inorganic substrate, surrounded by microbial extracellular products, which form an intermicrobial matrix. Organized in biofilms, microorganisms show higher resistance to both antimicrobial agents and host defence mechanisms when compared with planktonic cells.

First, it is currently difficult or even impossible to clinically diagnose extraradicular infections. Secondly, most endodontic medicaments are cytotoxic and/or may have their antimicrobial effects neutralized after apical extrusion.

Thus it is difficult to treat extraradicular infections with non-surgical treatment and hence they must be treated by means of periradicular surgery.

MICROBIAL INVOLVEMENT IN SPECIAL SITUATIONS

Overfilling

It has been claimed that the success rate of root canal treatment is decreased in cases of overfilling. Initially, the toxicity of root canal filling material was considered to be important in this respect, but most of the materials used in root canal obturation are either biocompatible or only show cytotoxicity while setting. It is highly improbable that most of the contemporary endodontic materials are able to induce inflammation in the absence of a concomitant endodontic infection. This is probably why a high success rate can be achieved for root canal treatment in teeth without periapical lesions even in cases of over-filling. The role of concomitant infection as an actual cause of failure of overfilled root canals emphasizes the need to properly prevent and control endodontic infection. Thus, failure associated with overfilled teeth is usually caused by a concomitant intraradicular and/or extraradicular infection. In most cases, apical sealing is inadequate in overfilled root canals 1, 45. It is well known that overinstrumentation usually precedes overfilling. In teeth with infected necrotic pulps overinstrumentation induces the displacement of infected dentine or debris into the periradicular tissues. In this situation, microorganisms are physically protected from the host defence mechanisms and thereby can survive within the periradicular lesion and maintain periradicular inflammation. The presence of infected dentine or cementum chips in the periradicular lesion has been associated

with impaired healing. Indeed, this is probably the most common form of extraradicular infection (45).
Coronal sealing

Coronal leakage may be an important cause of failure of endodontic treatment 45,48. Obturated root canals may be recontaminated by micro-organisms in a number of ways:

1) Delay in placing a coronal restoration following root canal treatment.

If a temporary restoration is of inadequate thickness, leakage will occur.

2) Fracture of the coronal restoration and/or tooth.

3) Preparation of post space for the provision of a post-retained restoration when the remaining apical section of the root filling is of inadequate density and/or length 12,48. Recontamination of the root canal system by coronal leakage will occur through: sealer dissolution by saliva; percolation of saliva in the interface between sealer and root canal walls (particularly if smear layer is present) and/or between sealer and gutta-percha. In addition, voids and other minor flaws in the obturation, which often are not detected radiographically, may be responsible for the rapid recontamination of the root canal system.

In such circumstances, if root canal obturation does not impede saliva leakage, microorganisms may invade and recolonize the root canal system. If microbial cells and their products reach the periradicular tissues, they can induce and/or perpetuate periradicular disease (45).

Nonmicrobial factors

Although most of the cases of root canal treatment failure are associated with intraradicular and/or extra radicular infections, it has been suggested that some cases can fail because of intrinsic or extrinsic nonmicrobial factors. In these cases, no microorganisms can be found, and failures have been attributed to a foreign body reaction in the periradicular tissues.

Cholesterol crystals are believed to be precipitated and accumulate as they are released from disintegrating host cells, including erythrocytes, lymphocytes, plasma cells and macrophages. These can be numerous in chronic periradicular lesions.They can also originate from circulating plasma lipids. It has been demonstrated that cholesterol crystals can be an aetiological factor in nonresolving chronic inflammation. If multinucleated giant cells are ineffective in removing crystals, they continue to accumulate and can maintain the periradicular lesion.

True cysts, which contain cavities completely enclosed by epithelial lining, do not heal by conventional root canal therapy.

Cysts containing epithelial lined cavities that are open to the root canals (bay cyst or periradicular pocket cyst) have a higher risk of becoming infected than true cysts. Within the cyst cavity, microorganisms egressing from the root canal system are combated by defence molecules (antibodies and components of the complement system) and by polymorphonuclear neutrophils that transmigrate through the epithelium into cyst lumen. Because of the morphological characteristics of the cyst cavity, the host defence mechanisms may not be effective in eliminating microorganisms. Persisting microbial cells and their products within the cyst lumen may maintain a periradicular inflammation in well-treated root canals. This also characterizes an extraradicular infection.

The cellulose component of paper points, cotton wool, and some food material of vegetable origin may also cause persistence of periradicular lesions, if placed into the periradicular tissues.

This stable polysaccharide of plant cell walls is neither digested by man nor degraded by the defence cells. As a result, cellulose can remain in the tissues for long periods and elicit a foreign body reaction. Paper points or particles thereof can be dislodged or pushed into the periradicular tissues, inducing a foreign body giant cell response or sustain the periradicular lesion (45).

According to Donald et al;

Prosthetic Failure

These types of failures Include failure of the restoration or an inability to further restore the tooth. The subgroups are: Crown fractures (Fig. 1), Root fractures (Fig. 2), Traumatic fractures, and Pathologic restoration.

Fig. 1- Crown Fracture: Crown fracture subgroup includes those teeth that have lost an artificial or natural crown and are deemed non restorable because of location of the fracture or carious destruction of the remaining tooth.

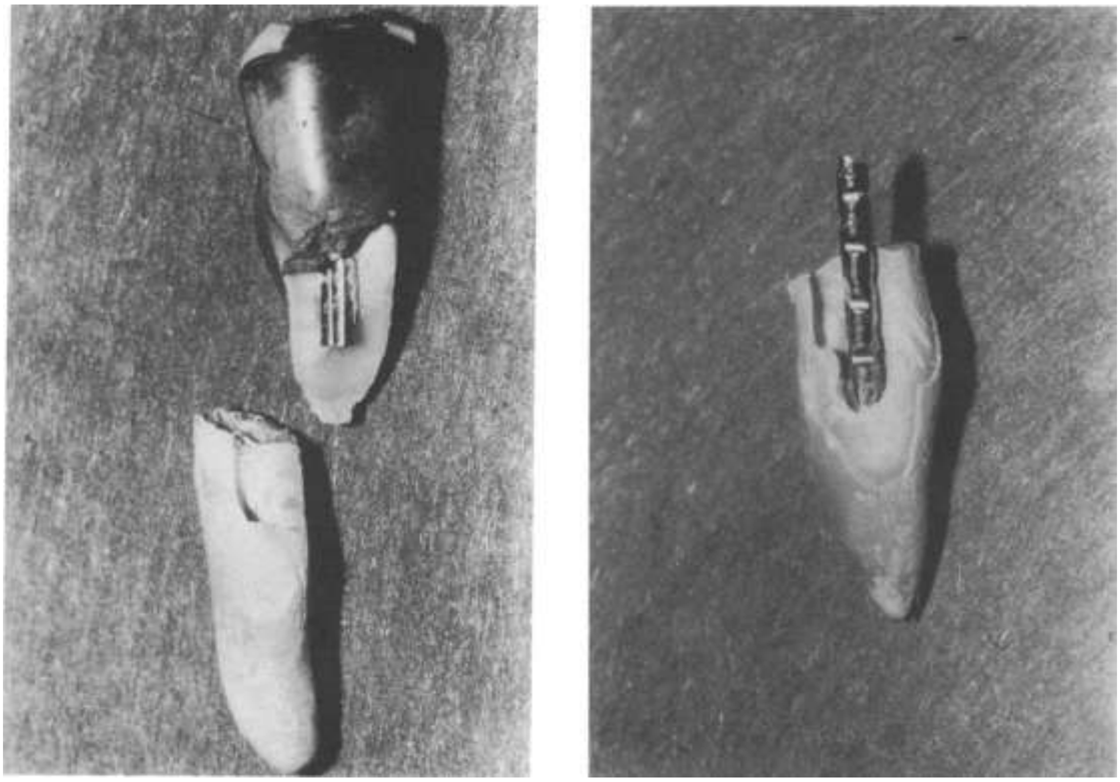


Fig. 2- Root fracture at the level of the post

The root fracture subgroup consists of those teeth in which fracture of the root occurs at the level of a post.

The traumatic fracture subgroup consists of teeth in which a recent traumatic episode has caused the tooth to fracture in such a manner that restoration is not feasible. An example of cases of pathological restoration is that in which a tooth with severe bone destruction from two pins was placed far into the furcation coupled with a massive amalgam overhang.

Comparing teeth with and without crowns demonstrated a significant difference in longevity. If a crown had been placed, the average time before extraction was 87 months. Without a crown, the average prosthetic failure occurred at 50 months.

Periodontal Failures

These teeth are usually quite mobile, are often symptomatic, and display radiographic bone loss.

Endodontic Failures

This category was further subdivided into three subgroups: vertical root fractures (Fig. 3), instrumentation failures such as strips, zips, and incomplete instrumentation, severe resorption which could have resulted from incomplete obturation. Mandibular teeth predominated over maxillary at a ratio of 7:3 47.

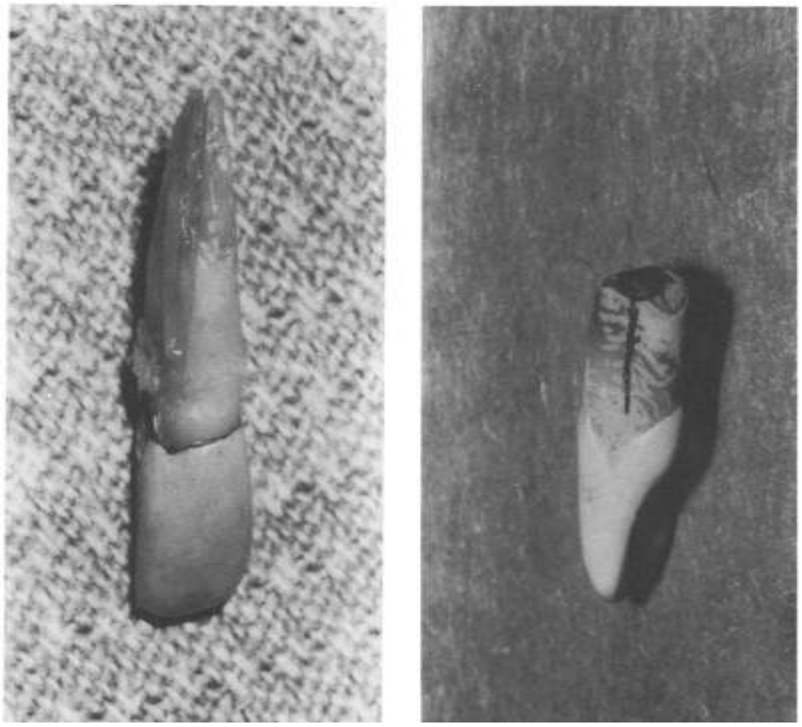


Fig. 3- Root fractures

Weine emphasized that a greater number of endodontically treated teeth are lost because of fracture because of improper restorations than because of poor endodontic result. The lack of pulpal sensation frequently allowed the decay process to continue without the patient seeking dental care.

PROCEDURAL ERRORS

Fractured Instruments

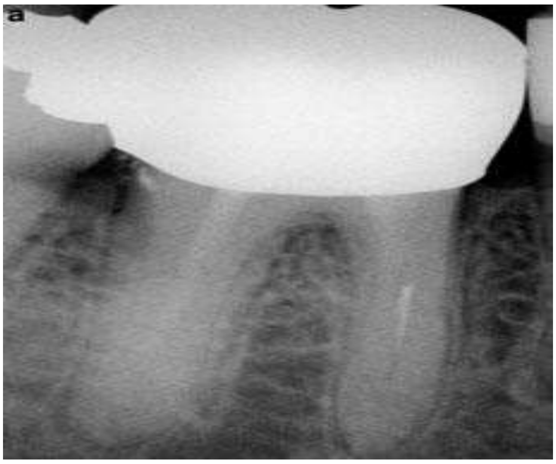


Fig. 4- Fractured instrument in the root canal

When an endodontic instrument fractures during use in a root canal (Fig. 4), the best option is to remove it. Only after removal of the fractured instrument can the root canal be negotiated, cleaned and shaped optimally. If the root canal cannot be cleaned and shaped successfully, remnants of pulp tissue and bacteria may remain and compromise the outcome of root canal treatment. However, attempts to remove fractured instruments may lead to ledge formation, overenlargement and transportation of the prepared root canal or perforation.

Due to their increased flexibility and elasticity the removal of fractured NiTi instruments may be more difficult compared with stainless steel instruments. An additional factor may be that when ultrasonic vibration is used in an attempt to loosen the fractured instrument from the root canal, the NiTi instruments have a greater tendency to fracture repeatedly. A further reason for the more difficult removal may be that many of the fractured NiTi instruments are „locked" into the canal because they may screw in.

The introduction of new devices such as the operating microscope, ultrasonic devices, Cancelliers (Carr 1992), hypodermic needles , blunt needle and core paste, Instrument Removal System (IRS) or the Tube-and-Hedstrom file- Technique may result in easier and more controlled removal of fractured instruments. The use of the operating microscope was essential for the removal of fractured instruments.

According to P. Sequeira et al 33, Curved canals are a higher risk for instrument fracture than straight canals. In curved canals rotary instruments (including lentulo spirals) fractured more often than other instruments. A decrease in success rate was evident with increasing treatment time. Attempts to remove fractured instruments from root canals should not take longer than 45–60 min. It is recommended that after this period of time serious consideration be given to other treatment options. The use of an operating microscope was a prerequisite for the techniques used to remove the fractured instruments (33).

Inability to Prepare to Length

Failure to achieve patency during preparation can result in inadequate penetration of irrigants. This could result in persistent infection and endodontic failure. The apical 3 mm of a root canal contains the highest percentage of lateral canals and deltas. Thus, if mechanical preparation, and consequently irrigant penetration, are 2–3 mm short of the constriction, the hypothetical length of canal that has not been disinfected could be as great as 6–7 mm.

Filing techniques such as the stepback methods can be fraught with instrumentation errors. Zips and elbows are not uncommon, as stiff stainless steel files used in a linear fashion tend to straighten the canals. These in turn are easily blocked with dentine chips that could potentially be infected. The development of nickel–titanium files with tapers greater than standard hand files has eliminated

the need to step back. This speeds up preparation and reduces the number of instruments that are required. These techniques have improved the ability to prepare canal systems predictably, while preventing blockage (1).

Missed Canals

A missed canal could harbour persistent bacteria. If a root-filled tooth appears satisfactory from a radiographic perspective but is still symptomatic, a missed canal could be suspected (Fig. 5). Maxillary first molars contain two canals in the mesiobuccal root in approximately 78% of teeth. Mandibular incisors have two canals in over 40% of cases and mandibular first molars frequently contain four canals (1).

Fig. 5- A case of missed second mesiobuccal canal (Left) and location and thereby obturation of the same during re-treatment (Right).

Ledges

Ledges are effectively an internal transportation of the canal and can be caused by a file working against compacted dentine chips. This infected material may harbour bacteria that could result in persistent inflammation.

Apical Transportation (Fig. 6)

Canals exhibiting apical transportation tend to be under-filled. There may be voids between the filling material and the canal walls in which bacteria could persist.

Fig. 6- Apical transportation

In both the above situations conventional retreatment is normally recommended, as the principal aim is to eliminate bacteria and related irritants from the root canal system (1).

Root perforations

Artificial communication between the root canal system and supporting tissues of the tooth or oral cavity lowers the prognosis of endodontic treatment, and often leads to extraction of the tooth. Ingle et al. have found that the second most common reason for failure associated with endodontic treatment is root perforation. Perforations can occur during operative procedures such as post preparation, as well as during endodontic treatment. The frequency of root perforations has been reported to range from 3% to as high as 10%. In addition, factors not related to operator mishaps such as pathological processes like root resorption or caries may result in root perforations. A perforation into the supporting tissues alone might not necessarily cause irreversible inflammation and failure. However, when a bacterial infection and/or an irritative restoration material is superimposed on the trauma of the perforation, healing will not take place. Consequences such as gingival downgrowth of epithelium into the perforation area , inflammation, bone resorption and/or necrosis can result. Repair of a perforation without periradicular inflammation may take place provided infection is avoided and asepsis maintained during treatment.

Classification of Perforations

• Lateral or furcal

• Fresh or old

• Small or large

• Apical-coronal or crestal

PROGNOSIS - Prognosis is dependant on the prevention or treatment of bacterial

infection of the perforation site. In addition, the use of a non-irritating material which seals the perforation will limit periodontal inflammation.

Good prognosis- Lateral, Small, Fresh and Apical-Coronal

Poor prognosis-Furcal, Large, Old and Crestal

"Fresh" is associated with a perforation at the same visit, which if treated immediately and with an aseptic technique has a good prognosis. "Old" perforations are associated with previously untreated accidental operative procedures where a bacterial infection may be established.

Small perforations are those which occur with endodontic instruments of size 15 or 20. Since the mechanical damage to the tissue as a result of these perforations is minimal and the chance that the perforation occurred under the aseptic conditions required of endodontic treatment (rubber dam, sodium hypochlorite irrigation etc.) fairly good, infection is less likely. For these reasons small perforations are placed in the good prognosis category. A large perforation such as that which occurs in post preparation results in significant tissue damage and the chances of infection from saliva or leakage are much greater. Therefore, the prognosis in these cases is considered poor.

CORONAL= coronal to the crestal bone and epithelial attachment and has a good prognosis.

CRESTAL= at the level of the epithelial attachment and crestal bone and has a Poor prognosis.

APICAL= apical to the crestal bone and epithelial attachment and has a good prognosis.

Lateral is placed in the good prognosis and furcation in the poor prognosis columns since the furca is usually close to the crestal bone while lateral could be coronal or apical as well.

Several factors related lo infection of the perforation site affect the prognosis of the treatment of root perforations, the most important of which are: time between occurrence and treatment, size, and location of the perforation.

TIME- The time between the occurrence of the perforation and when appropriate treatment is performed has been found to be an important factor in healing. The most favorable healing occurrs when the perforations are sealed immediately. Thus, reducing the likelihood of an infection being established resulting in a better peri radicular environment around the perforation.

SIZE-The size of a perforation also has an important effect on the prognosis of treatment. A small perforation is usually associated with less tissue destruction and inflammation; therefore healing- is more predictable. It was found that the prognosis of treatment was directly proportional with the size of the tooth: the larger teeth (with proportiotially smaller perforations) had the best results. Since the aim of obturating materials is to prevent bacteria from the oral cavity from reaching the periradicular tissues, and to avoid irritation of the periodontal tissues by extrusion of sealing materials, it appears logical that small perforations have a better prognosis because they are easier to seal effectively without forcing the filling material into the surrounding tissues.

LOCATION- The location of a perforation is probably the most important factor affecting tooth prognosis. Close proximity of the perforation to the gingival sulcus can lead to contamination of the perforaton with bacteria from the oral cavity through the sulcus. Furthermore, if the wound is large and not treated immediately, the proximity to the epithelial attachment is critical and apical migration of epithelium to the perforation site will create a periodontal defect. Thus a critical zone in terms of prognosis is the level of the crestal bone and the epithelial attachment. Perforations which are located coronal lo this zone have a good prognosis. Access to the perforation is attainable, and adequate sealing is possible without periodontal inivolvement. Crestal root perforations are most susceptible to epithelial migration and rapid pocket formation, thereby having the lowest success rate of repair. Perforations which are located apical to the critical zone should have a good prognosis provided adequate endodontic treatment is rendered, and the main canal is accessible. Wounds created into the periodontal ligament below the level of the epithelial attachment from the the pulp chamber may heal without periodontal involvement (49).

Furcal perforations

Perforations in the furcation area of multirooted teeth are regarded usually as critical root perforations because of the proximity to the epithelial attachment and the gingival sulcus. Seltzer et al have stated that perforations of the furcal region of molars are especially troublesome because they cause considerable damage and frequently lead lo periodontal involvement of the furcation. Beavers et al. however, showed a 100% success rate in treatment of furcation perforations.

Treatment of perforations

Localization of the perforation

When located on the buccal or lingual aspects of the root, the perforation is superimposed radiographically on the root surface. The clinician should probe the gingival sulcus to evaluate possible communication with the oral cavity. An apex locator is helpful in locating the exact position of the communication with the periodontal ligament. Once the apex locator has indicated when the periodontal ligament has been reached, it is prudent to take a radiograph to assess its relationship to the critically important level of the crestal bone. Generally, nonsurgical treatment is indicated in the management of root perforations, while surgical inter- vention is reserved for cases not amenable to, or those that have failed in response to nonsurgical treatment or where a concomitant management of the periodontium is indicated.

Nonsurgical treatment

The rationale for nonsurgical treatment of root perforations is the same as that of a conservative endodontic procedure, namely, the prevention or treatment of periradicular inflammation. This is achieved by ensuring that the perforation site is either not infected or disinfected at the time of treatment, that the material used to treat the perforation provides the best possible seal to bacterial penetration and that the material is itself not irritating to the surrounding tissues.

1. **Lateral Perforations**

Coronal Perforations- Coronal root perforations should not be difficult to seal externally, and the material selected for sealing will depend on esthetic considerations. Acid etch bonded composite resins or glass ionomer cements may be used in anterior teeth, whereas amalgam is an additional option in posterior teeth.

Crestal Perforations- Crestal root perforations are the most difficult to manage because of their proximity to the epithelial attachment, and possible communication with the gingival sulcus. With large crestal perforations whether fresh or old, surgical intervention will usually be necessary in order to seal the defects externally. A further possibility is orthodontic extrusion of the tooth to bring the perforation to a coronal position where it can be sealed without surgical intervention. Any biocompatible material, with a short setting time, should be selected for such cases to minimize the effect of the unset material on the periodontal tissue with which it is in contact.

Apical Perforations- Apical perforations should be treated according to routine endodontic principles for regular root canals. A main difficulty usually will be to access and adequately treat the main root canal. Apical, small and fresh perforations should preferably be completed in one visit, and the perforation sealed with gutta-percha and root canal sealer. The use of an aseptic technique is essential. Apical, small and old perforations have to be treated with an antibacterial intracanal medicament such as calcium hydroxide, and sealed with the main canal at the second visit. Apical, large and old or fresh perforations should be treated like teeth with immature apices i.e. with long term calcium hydroxide treatment. Calcium hydroxide is used as an intracanal medicament for several months until a hard tissue barrier is formed and regular root canal obturation can be carried out In cases where the original canal is not accessible, and apical periodontitis develops, root end resection is indicated.

2. **Furcation perforations**- Perforations of the furcal region (Fig. 7) of molars are difficult because they cause considerable mechanical damage and frequently lead to communication with the sulcus.

Fig. 7- Furcal perforations

Apical small furcation perforations, if sealed by a fast setting material will have a favorable prognosis. However, large furcation perforations make control of the repair material difficult, and extrusion of the filling material into the periodontal ligament space is common. Grossman found amalgam to be a favorable material. Aguirre et al. suggested the use of indium foil for the repair of extensive perforations in the floor of the chamber. The foil acts as a matrix over which amalgam is condensed, thus confining the materials within the tooth. Webber suggests the preparation of a retentive groove around the perforation on the floor of the chamber to allow condensation of amalgam onto the line angles, which may reduce the chance of gross overfilling.

Materials

Another approach is to apply materials such as calcium hydroxide, tricalcium phosphate, hydroxyl apatite, or dentin chips in order to accomplish a calcified barrier against which to condense a filling material similar to amalgam. However none of these materials were superior to filling materials such as amalgam, cavit, zinc oxide eugenol or gutta-percha.

By placing materials such as calcium hydroxide in perforations that are adjacent to the crestal level, the resultant necrotic zone can reach the epithelial attachment, thus compromising the prognosis. The rationale for treatment of uncertain cases should be immediate sealing with a biocompatible material that possesses minimal or non-irritating characteristics after a fast set.

Glass ionomer cements, bonded resins or mineral trioxide aggregate are newer materiais suggested as alternative retrofilling materials which might possess some of these properties (49).

There are three materials that are in common use 1:

- Biodentine
- Mineral trioxide aggregate
- Ethoxybenzoic acid
- Intermediate restorative material

Biodentine

In a study by Gunesar et al67, Biodentine showed considerable performance as a repair material even after being exposed to various endodontic irrigation solutions, such as Naocl, cholorohexidine, saline.

Mineral Trioxide Aggregate (Fig. 8)

Fig. 8- Mineral Trioxide Aggregate

MTA has been recommended as a root-end filling material and for the repair of perforations. It has excellent biocompatibility when compared with other root-end filling materials. Formation of a new cementum layer has been shown when MTA has been used to repair perforations. The material is able to set and form a seal even in the presence of water or blood. MTA (Fig. 8) comes as a powder and is mixed with sterile water to a slurry consistency. It can be a difficult material to handle, has a long setting time (2 hours 45 minutes) and normally requires a two- visit approach for perforation repair. Radiographically, the material appears slightly more opaque than gutta percha.

Super Ethoxybenzoic Acid

Fig. 9- Super Ethoxybenzoic Acid

Super EBA is a modified form of zinc oxide–eugenol cement. Orthobenzoic acid forms part of the liquid component and aluminium oxide is added to the powder. The material has a neutral pH and low solubility. It will adhere to dentine in the presence of moisture or blood contamination and periapical tissue repair has been demonstrated when it has been used as a root-end filling (Fig. 9). EBA cement has a relatively short working time and tends to adhere well to most surfaces. It can therefore be difficult to handle. The material has similar radio-opacity to gutta percha.

Intermediate Restorative Material

Fig. 10- Intermediate Restorative Material

IRM is a reinforced zinc oxide–eugenol cement. It has been used as a root-end filling material with good results (Fig. 10). When used in root-end surgery the material is mixed with a high powder/ liquid ratio to reduce the irritant effects of the eugenol, increase setting time, enhance placement and reduce dissolution in tissue fluid. It has a good working time and is radio-opaque.

Strip perforation repair

A strip perforation can be caused by over-use of Gates–Glidden burs or rotary coronal flaring instruments. The resultant defect is a narrow slit-like perforation on the internal curvature of the root canal. A strip perforation can be detected using an apex locator but will be easier to repair if it is visible under the operating microscope.

Preparation and cleaning are completed in the usual manner using irrigants such as sodium hypochlorite and EDTA. Endosonics can also be useful for delivering irrigant. The solutions should percolate into the strip perforation and bathe the defect. It is very important that the irrigant is delivered passively and that the solutions are not injected through the perforation and into the bony crypt. Following cleaning, the canal is dried, and in most instances a medicament such as calcium hydroxide is packed into it. At a second appointment, the medicament is washed out of the root canal system using sodium hypochlorite and EDTA. The canal is then dried with paper points. If a small plugger can be inserted to within 3 mm of the working length, MTA can be used to obturate the entire canal and, in doing so, the defect will be sealed (Fig. 11). If the apical region is too small or inaccessible due to excessive curvature, it is obturated with gutta percha and sealer and then finished just apical to the strip perforation. The remainder of the canal is then packed with MTA. A damp pellet or sponge is sealed into the access with IRM. At a further visit it is confirmed that the MTA has set.

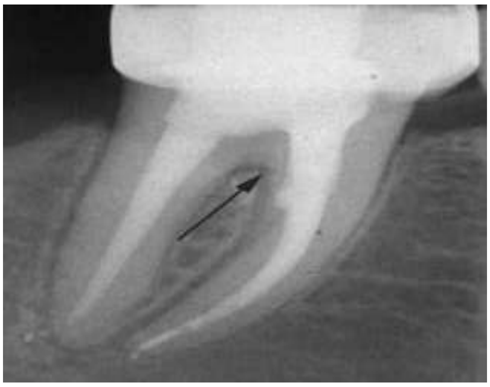


Fig. 11- Sealing of strip perforation with MTA

Another technique for obturating the entire canal involves mixing the MTA slightly wetter than usual and placing it into the root canal. A short burst of ultrasound transmitted through it with an endosonic file causes the MTA to slump into the root canal.

Post space perforation repair

In case of a post space perforation the previous restoration is dismantled and the root canal cleaned with irrigants. The perforation should be cleaned passively with irrigant solutions. There is often granulation tissue present in the defect, and this has to be displaced to allow the placement of perforation repair material.

Lemon introduced the „internal matrix concept" for the treatment of such root perforations. In this technique hydroxyapatite used as the external matrix and the defect was filled with amalgam. The technique has been modified for use with MTA. Because MTA does not require a firm barrier like amalgam to pack against, a resorbable collagen matrix can be used.

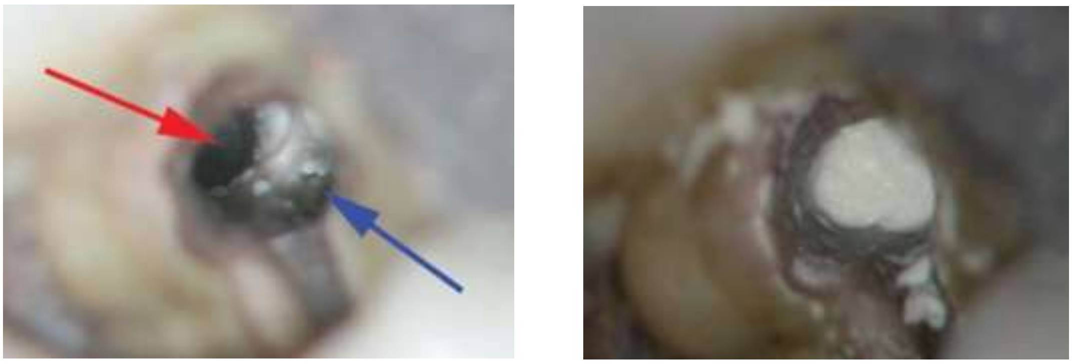


Fig. 12- Post space perforation (left) and its repair with MTA (Right)

Collecote is packed through the defect and used to push any granulation tissue extraradicularly. MTA can then be placed into the defect with an MTA gun or picked up on a plugger tip and packed into place (Fig. 12). Direct visualization is important to prevent material occluding the root canal space. This technique has been shown to be effective in clinical use. If the defect cannot be visualized, a surgical approach may be more effective.

DECISION MAKING AND TREATMENT PLANNING

The decision-making process for endodontic retreatment can be complex. This is highlighted by the substantial variation that is seen amongst clinicians in the management of endodontically treated teeth with symptom-free periapical lesions. Factors contributing to differences in decision-making processes amongst groups of clinicians include the dentist, the patient, cost, environmental resources, clinical experience, training and speciality.

If root canal treatment has failed, there are usually five possible treatment options:

● Review or do nothing
● Root canal retreatment
● Root end surgery
● Extraction
● Referral

Review or do Nothing

There may be occasions where a conservative approach is appropriate. The balance of factors to consider in a case of failed root canal treatment, where review is considered, include an assessment of the risk of future disease against the risk of leaving untreated disease. The majority of treated cases that develop apical periodontitis will do so within 1 year. Failure after 1 year is infrequent and therefore observation at this time will, give a good indication of outcome.

Review may be considered when:

● The tooth is symptom-free
● There is no systemic risk by no intervention
● There are no signs of inflammation or infection
● The tooth does not require a new restoration

● Root canal treatment has only recently been completed and the outcome is uncertain.

Root Canal Re-treatment

Root canal retreatment is often the preferred means of treating a failed root canal procedure, especially when the failure is due to a technical deficiency. Root canal retreatment is often much more complicated than initial treatment as restorations may need to be dismantled in order to gain access to the canal system. The risks encountered during retreatment include possible weakening of the existing tooth substance, damage to existing coronal restoration, difficulties in removing posts or existing root fillings and the challenge of negotiating iatrogenic difficulties.

Root canal retreatment is normally indicated when:

- Conventional root canal treatment has failed
- There are signs of inflammation or infection associated with a root-filled tooth
- There are persistent symptoms from a root filled tooth, or the presence of a sinus tract, swelling or pain
- A root-filled tooth has failed for technical reasons
- There is systemic risk if no intervention is made
- The tooth is restorable
- The tooth has evidence of periapical radiolucency and requires a new restoration
- The existing root filling is technically deficient and a new restoration is required
- The patient conserts to retreatment.

Root End Surgery

A surgical approach is normally reserved for cases in which apparently good- quality root canal treatment or retreatment has been unsuccessful.

Fig. 13- Root end surgery

Root end surgery (Fig. 13) may be considered when:

- It is impractical to carry out conventional root canal retreatment, e.g. if a very large post were well cemented in an already weakened root, resulting in a high risk of fracture on removal
- Root canal treatment or non-surgical retreatment has been unsuccessful
- As an adjunct to root canal retreatment, perhaps in perforation repair or to remove extruded material
- When root or tooth resection is required
- When a biopsy is required
- For investigation and exploration, e.g. in a case of root fracture
- Patient preference, following assessment of risk.

Extraction

If a tooth is unrestorable or the prognosis for root canal retreatment is poor, extraction is the only option (Fig. 14).

Fig. 14- Weakened root due to a large post

Extraction may be the treatment of choice:

- When the tooth or root is fractured and is not saveable
- If an alternative, such as removable or fixed bridgework or an implant-based solution, would offer a better prognosis
- When the patient elects not to have retreatment
- When all options have been explained
- When root canal retreatment is unlikely to be successful.

Referral

Surgical and non-surgical procedures are often technically demanding and the results achieved dependent on operator skill. Complicated cases may be preferentially referred to a specialist or highly experienced colleague.
Referral may be appropriate when:

● The clinician is unable to make a diagnosis
● Access is limited
● Root canal treatment has failed
● Retreatment has failed
● Complexity of treatment is greater than the clinician"s expertise
● Surgical endodontic treatment is required
● Patients present with complex medical histories
● Combined multidisciplinary problems
● Patient requests referral.

Treatment Planning

General patient attitudes will influence treatment planning. The motivation to retain teeth, to pursue the best long-term treatment option and to spend time and money will vary between patients. This may be a primary consideration in the treatment planning process. if a patient is not motivated to save teeth, extraction may be appropriate.
Once a decision has been made to carry out retreatment, the clinician must decide whether a surgical, non-surgical or combined approach is most appropriate. The chance of teeth with no periapical pathology remaining symptom free following root canal treatment or nonsurgical retreatment has been shown to be 92–98%.

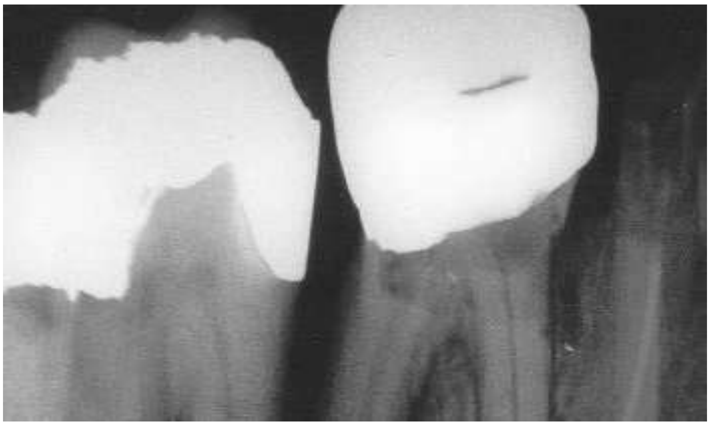
Conservative endodontic therapy, both nonsurgical and surgical, is therefore definitely justified and should be attempted when a good restorative and periodontal prognosis is projected, unless the patient is not motivated to retain the tooth. The long-term success rates for surgical endodontics appear to be no better than a conventional approach. However, Surgical intervention is a far more radical procedure, generally demanding more expertise and resulting in a shortening of the clinical root length. Unless the reservoir of infection is eliminated, it is likely to continue causing persistent periapical inflammation or failure of treatment.

Non-surgical root canal retreatment is often the most appropriate means of treating failed root-filled teeth in the first instance and that teeth should be permanently restored soon after retreatment to increase the chance of success. A surgical approach is normally reserved for situations in which, despite a good attempt at non-surgical retreatment, the tooth still presents with signs and symptoms.

Gaining access to the root canal system

The quality of coronal seal should be assessed preoperatively. Where a crown is leaking or has been undermined by recurrent caries (Fig. 15), it should be removed 1. All restorations of poor quality, poor marginal adaptation, and those that present with recurrent caries should be removed completely to facilitate the retreatment process 50. But it should be noted that working through a crown is always more difficult, and that damage can be done. Just piercing the glaze of a porcelain crown dramatically reduces its strength, whilst cutting through a metal ceramic crown can weaken the porcelain bond and predispose to fracture. Vibration can disturb the cement lute of a casting and predispose leakage or loss, whilst rubber-dam clamps may crack and pit cervical porcelain and occasionally cause a crown to debond. Once through the crown, the search for the pulp can be hazardous. Metal copings and cores obscure the pulp and prevent its location and assessment from preoperative radiographs. The alignment and rotation of the crown may also not correspond to the underlying tooth, causing loss of orientation and misdirected cutting. Added to this, problems are compounded by limited entry of light and poor visibility. All of this can leave the operator severely weakening the core and vertical walls of the tooth in search for the pulp chamber and canal openings. Catastrophic errors such as perforation are also possible (51).

Fig. 15- Crown undermined by caries



Endodontically, the decision to remove the coronal restoration is due primarily to the requirement of additional access to facilitate the retreatment process. Removal of the coronal restoration allows for enhanced assessment of tooth morphology. Furthermore, radiographic information such as the identification of perforations, untreated root canal systems, and the coronal extent of silver cones can be detected. Vertical fractures also may be identified easier once the restoration is removed, and enhanced access for the clinician also can be obtained (50).

DISMANTLING CORONAL RESTORATIONS

Chisel, Flat Plastic and Coupland‟s Chisel (1)

Fig. 16- Coupland's chisel

Careful placement of a chisel, flat plastic or Coupland‟s chisel (Fig. 16) into a marginal deficiency can be sufficient to cause the cement lute to fail. Force should be applied along the path of insertion (Fig. 17) to avoid fracture of the underlying tooth substance and core material. The chisel should be held in the palm of the hand with the forefinger near the tip so that if the instrument slips there is no risk of injury to the patient. The margin of the crown can be undermined using a small diamond bur or an ultrasonic tip, creating a gap into which the chisel is placed. An access cavity can be cut in the occlusal surface and the instrument inserted between underlying core material and the crown. By cutting an access cavity, retention of the crown is significantly reduced and should therefore make crown removal easier. When removing anterior crowns, it is sometimes possible to cut a groove in the palatal aspect of the crown into which a flat plastic or Coupland‟s chisel can be inserted.

Fig. 17- Path of insertion of anterior crowns

Flexing the crown allows removal so that the restoration may be recemented as a temporary.

Forceps

Special forceps for crown removal are available with rubber cups on the beaks (Fig 18).

Fig. 18- Crown removal forceps   Fig. 19- Carborundum powder

These are coated in carborundum powder (Fig. 19) to prevent slipping. Generally, forceps are applied to the crown that needs to be removed and a gentle wiggling action used to loosen the restoration. One must be careful not to damage adjacent or opposing teeth.

Crown removers

This instrument consists of a hook that is inserted under the margin of a restoration. The hook is in turn connected to a rod with either a weight or a spring loaded device which can apply a sudden force to break the cement lute.

The WamKey

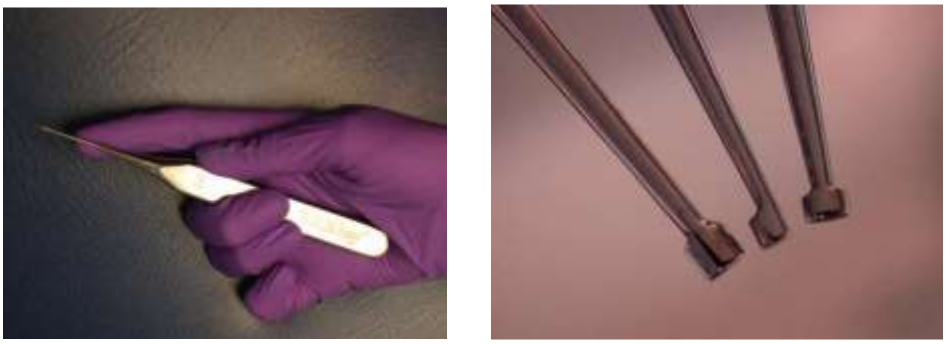


Fig. 20- The wamkey

The WamKey looks rather like a small key and can be effective for crown and bridge removal (Fig. 20). A small access is cut in the buccal or lingual surface of the crown such that space is made between the underside of the restoration and any core material.

Fig. 21- Removal of the crown using the wamkey

The key is then inserted and, when rotated, separates the crown from the underlying core material (Fig. 21).

Coronaflex crown remover (1)

This is an air-driven device that connects to standard dental handpiece hoses via KaVo's Multiflex coupler (Fig. 22). The crown remover delivers a controlled low amplitude impact at its tip. The device works well on FPDs and is well-tolerated by patients.

Fig. 22- Coronaflex crown remover

The kit includes loops to thread under FPD connectors that attach to a holder, calipers, and an adhesive clamp to obtain a purchase on single crowns (Fig. 23). The goal is to deliver the impact in the long axis of the abutment tooth.

Fig. 23- The Coronaflex crown removal kit

The loop is threaded under the connector (Fig. 24). The tip of the crown remover is placed on the bar, and the impact is activated by releasing the index finger from the air valve.

Fig.24- Removal of the crown using the coronaflex crown remover

The adhesive clamp is attached with autopolymerizing resin used to remove a single crown (Fig. 25).

Fig. 25- The adhesive clamp

Roydent Bridge and Crown Remover

This device is designed to grip a crown or FPD and to deliver a removal force along the long axis (Fig. 26).

Fig. 26- Roydent Bridge and crown remover

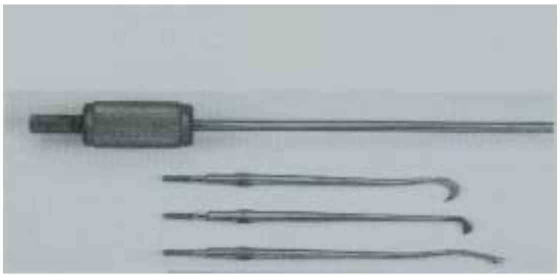


Fig. 27- Back-action Crown remover

Fig. 28- Spring-activated Crown remover

Fig. 29- Pneumatic Crown remover

Richwell Crown and Bridge Remover

It has an adhesive resin tablet (Fig. 30), which is softened in warm water for 1 to 2 minutes, and the patient is instructed to occlude into it.

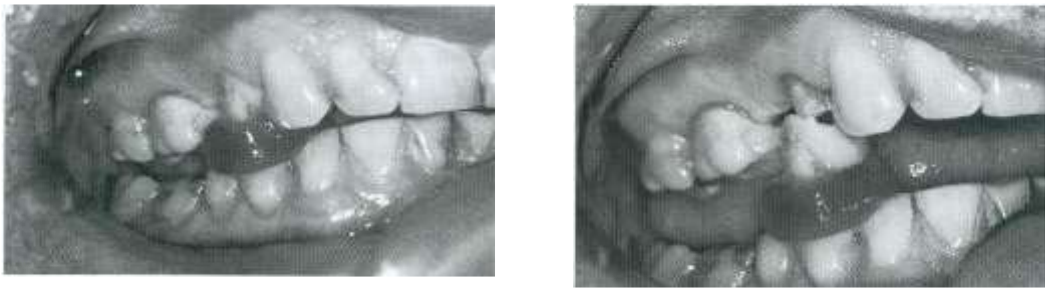


Fig. 30- Richwell Crown and Bridge Remover

The resin is cooled with water. A sharp opening action should remove the crown.

Care is needed to avoid removing a restoration in the opposing jaw.

Removal of an existing crown by sectioning

The restoration is carefully sectioned, initially cutting just through the ceramic to the metal.

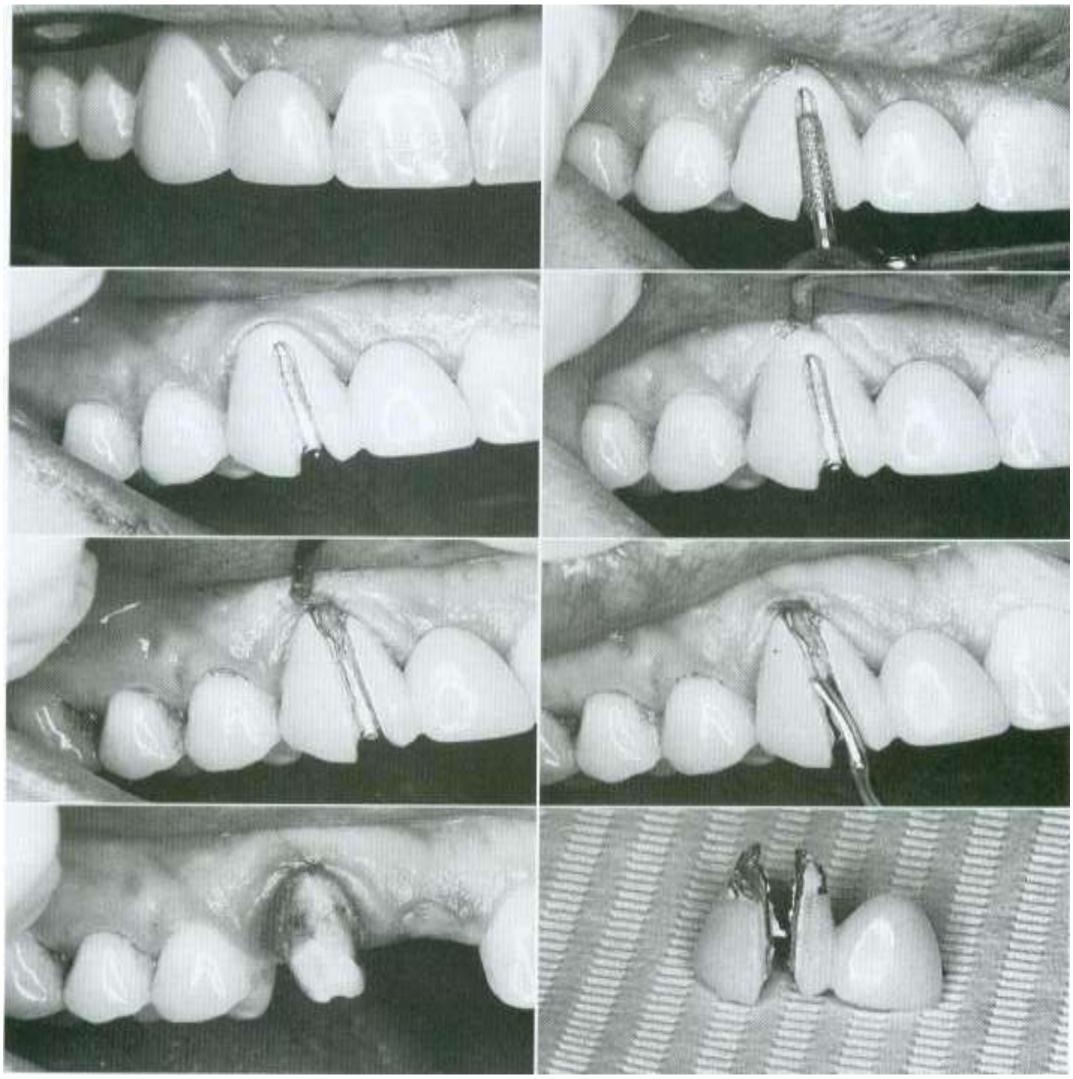


Fig. 31- Removal of a crown by sectioning

It is easiest to do this on the facial and incisal surfaces. The goal is to cut just through the metal to the cement and follow the cement toward the gingival margin.

(Fig. 31). Displace the gingiva with an instrument and carefully section the crown to the gingival margin. Place a suitable instrument (e.g., a cement spatula or sterilized screwdriver) in the cut and gently rotate to force the halves of the crown apart. It may be necessary to section part of the lingual surface to facilitate this step (52).

REMOVAL OF POSTS

When endodontic treatment is failing, the need arises to remove a post to facilitate successful nonsurgical retreatment. Many techniques have been advocated for the removal of posts and other large intracanal obstructions.

Factors Influencing Post Removal

There are many factors that influence successful post removal such as operator judgement, training, experience, and utilizing the best technologies and techniques. It is important to know tooth morphology including the length, circumferential dimension and curvature of any given root including, if present, the depth of an external concavity. This information is best appreciated by obtaining three well angulated pre-operative radiographs. Films also assist the clinician in visualizing the length, diameter and direction of the post, and aid in determining if it extends coronally into the pulp chamber. Other factors influencing post removal are the post type and cementing agent.

Posts can be catalogued into parallel versus tapered, active versus non-active, and metallic versus new, non-metallic compositions (53). It has been demonstrated that parallel-sided posts may resist tensile forces as much as 4.5 times more than tapered dowels (22).

Posts retained with the classic cements like zinc phosphate can generally be removed; however, posts bonded into the root canal space with materials like composite resins or glass ionomers are often times more difficult to remove.

Other important factors that impact post removal are the available inter-occlusal space, existing restoration, and whether the coronal most aspect of the post is supra or subcrestal. Post removal becomes more challenging moving from anterior to posterior teeth. The difficulty in removing a post substantially increases in furcated teeth containing multiple posts joined coronally with single or multiple interlocking key-ways 48. Increased post length results in increased retention. One study demonstrated as much as a 30% increase in post retention with as little as a 2 mm increase in post length (22).

When evaluating a tooth for post removal, the clinician must weigh risk versus benefit before proceeding with this procedure. A root can be structurally weakened, perforated or fractured during any phase of retreatment ranging from radicular disassembly to subsequent shaping and filling procedures. In some instances, it may be wise to consider a surgical approach to resolve an endodontic failure (53).

The emergence of ultrasonics and its implementation into endodontics has provided clinicians with a useful adjunct for post removal. Ultrasonic energy has proven effective as an adjunct in removal of silver points, fractured instruments, and cemented posts. Ultrasonics are significantly more efficient than sonic instrumentation in reducing the amount of time required to dislodge a cemented 4- mm-long prefabricated post under a constant tensile force.

Yoshida et al. found that simultaneous application of two ultrasonic tips on either side of the cemented post further decreased the amount of lateral vibration required to extract cemented dowel-retained cast cores under intermittent tension. Buoncristiani et al. have suggested that the viscoelastic nature of the plastic in resin cements tends to dampen vibrations and absorb ultrasonic energy transmitted to the post. Resin cements are less brittle and may not tend to microfracture like zinc phosphate. Higher retentive values with resin cement than with zinc phosphate or glass ionomer cements have been reported. Dentin adhesive agents have also been found to enhance retention when used with resin cements. Resin cements generally provide greater post retention than other cements.

If ultrasonics prove less useful in removal of resin-retained posts, clinicians might consider the earlier use of a post-pulling device or reconsider a surgical approach instead of nonsurgical retreatment (22). The use of ultrasonics has been suggested to interrupt the integrity of the cement by vibration to facilitate post removal. A reduction in tensile failure loads of intraradicular posts cemented with zinc phosphate cement after ultrasonic vibration has been noted.

Multiple studies have shown retention is considerably influenced by fit of the post. A larger diameter, and therefore better adapted, post consistently requires a greater tensile force to break the cement seal and free the post. Additionally a well adapted post inherently minimizes the film thickness of cement. The ideal cement film thickness should be between 25 to 35 mm. A thicker layer is inconsistent with optimum cement tensile strength, causing reduced post retention (22).

Techniques for Access (53)

Successful post removal requires sufficient access so all restorative materials from the pulp chamber can be eliminated. Coronal disassembly improves access, vision and the retreatment efforts. When post removal procedures are performed through an existing restoration, then high speed rotary cutting tools are utilized to prepare a lingual or occlusal window, section and eliminate the core, and create straightline access into the pulp chamber. The #2 and #4 round bur diamonds, in conjunction with water, are utilized to more safely brush-cut through tooth- colored restoratives such as porcelain. The transmetal bur is the bur of choice for cutting metal because the sawtooth configuration of its blades reduces unwanted vibration when cutting various types of precious and nonprecious metals. Surgical length, #2 and #4 carbide round burs provide extended reach which improves access and vision into the pulp chamber. Round burs efficiently remove dentin and the restorative materials that commonly entomb the head of a post. Surgical length tapered diamonds are advantageously used with a light brushing motion to refine, smooth and flare the axial walls and finish all aspects of the access preparation.

Piezoelectric technology in conjunction with ultrasonic instruments provides important advantages when performing access refinement procedures. Advantageously, small profiled ultrasonic instruments afford continuous and improved vision into the field of operation. A rotating bur in a dental handpiece is oftentimes difficult to see because even a small sized head oftentimes blocks the line of sight.

Thinner and more parallel-sided ultrasonic instruments are designed to work in smaller spaces such as between a post and an axial wall. Importantly, a parallel sided ultrasonic instrument may be safely used below the orifice and lateral to a post, especially in an irregularly shaped canal. Ultrasonic instruments are best utilized with a light brushcutting motion and on the peripheral edge of a sectioned core to chip, break up and sand away materials such as cement, composite or amalgam. Eliminating these materials from the pulp chamber serves to undermine the retention of a post. To optimize vision, virtually all nonsurgical ultrasonic procedures are performed dry. When an abrasively coated ultrasonic instrument contacts, brushes and sands away dentin or a restorative material, then the byproduct of this work is dust. The assistant utilizes the Stropko three-way adapter with the White Mac tip to direct and control a continuous stream of air into the field. This clinical action serves to blow out debris and, importantly, allows the clinician to maintain visual contact at all times on the energized tip of the instrument.

Water port technology in nonsurgical ultrasonic instruments is contraindicated for four important reasons:

1. Water flowing through an ultrasonic instrument dampens movement and decreases tip performance.
2. Small diameter ultrasonic instruments are weakened and more predisposed to expensive breakage when they are machined for internal water flow.
3. There is an undesirable aerosol effect regardless of where the water port is positioned on an ultrasonic instrument.
4. Water in combination with dentinal dust, creates mud, lost vision and the potential for iatrogenic outcomes.

However, if ultrasonic procedures are performed at higher energy levels, for longer periods of time, and against larger, conductive objects, such as a metal post, then it is critically essential that the dental assistant use a triplex syringe with an intermittent water spray to reduce heat build-up and transfer. Fortunately, heat does not conduct well through dentin and is further rapidly dissipated due to the moisture content in the attachment apparatus.

Rotosonic Vibration

Rotosonics is a straightforward method to potentially loosen and remove a fully exposed post. The Regular Tip Roto-Pro bur is a highspeed, friction grip bur whose six faces are joined by six edges and when rotated one revolution, its edges produce six vibrations per revolution. When the instrument is rotated at 200,000 RPM, it produces 1.2 million vibrations per minute, or 20,000 vibrations per second. This instrument provides an inexpensive method to remove certain posts.The bur is kept in intimate contact with the obstruction and is generally carried counterclockwise around the post. Clinically, rotosonic vibration provides a low tech method to potentially remove a post retained with a more traditional cement such as zinc phosphate (53).

Ultrasonic Energy

The ultrasonic energy utilized in endodontic devices is generated by one of two types of ultrasonic transducers that convert one form of energy into another. Piezoelectrical (Pi) transducers produce ultrasonic energy by transforming electricity into ultrasonic vibrations. Crystals within the transducer (usually made of quartz) are vibrated by the electricity flowing through them. By applying an alternating electrical field across the crystals, the quartz is compressed and released producing vibration of the tip. Magnetostrictive (Ma) transducers use ferromagnetic materials and certain nonmetals called ferrites. A change in dimension occurs when a rod or bar of this material is subjected to an alternating magnetic field producing vibration of the tip. Pi and Ma devices also produce noise and heat (29, 30). The most active distal end of an appropriately designed ultrasonic instrument is kept in intimate contact with the post to maximize energy transfer and promote cement/bond failure. The selected ultrasonic instrument is energized and moved around the post circumferentially and up and down along its exposed length. The by product of ultrasonic energy is heat (53). Heat is produced from ultrasonic devices through three different mechanisms. First, via friction created between the titanium post and the ultrasonic tip. Secondly, via the temperature of the coolant flowing through the handpiece. Thirdly, via acoustic energy absorption of ultrasound transmitted to the tooth (30). When performing ultrasonic procedures for longer periods of time and against larger conductive metal posts, the field should be frequently flushed with water to decrease heat buildup and the potential for dangerous heat transfer to the attachment apparatus. Experience suggests that after removing all circumferential restorative materials, the majority of posts can be safely and successfully removed within approximately 10 minutes (53).

Mechanical Option

A number of different devices have been designed to mechanically remove a post. However, many of these devices, such as the Masserann kit (Micromega) and the Post Puller (Brasseler) have had limited success because they frequently require the excessive removal of tooth structure, which predisposes to ledges, perforations or root fractures. The Gonon post extractor (EFDM-Pneumat) represents a definite improvement over the Masserann and the Post Puller devices in that it is less invasive (5).

The Gonon PRS (Post Removal System) is designed to mechanically engage and remove different kinds of post types or other intracanal obstructions whose cross- sectional diameters are 0.60 mm or greater (Fig. 32). The PRS kit contains extracting pliers, a trans metal bur, five trephines of varying internal diameters, five corresponding tubular taps whose internal diameters range from 0.60-1.60 mm, a torque bar, tube spacers, and a selection of rubber bumpers. The preparatory procedures before utilizing the PRS require straight line access and complete circumferential visualization of the post within the pulp chamber.

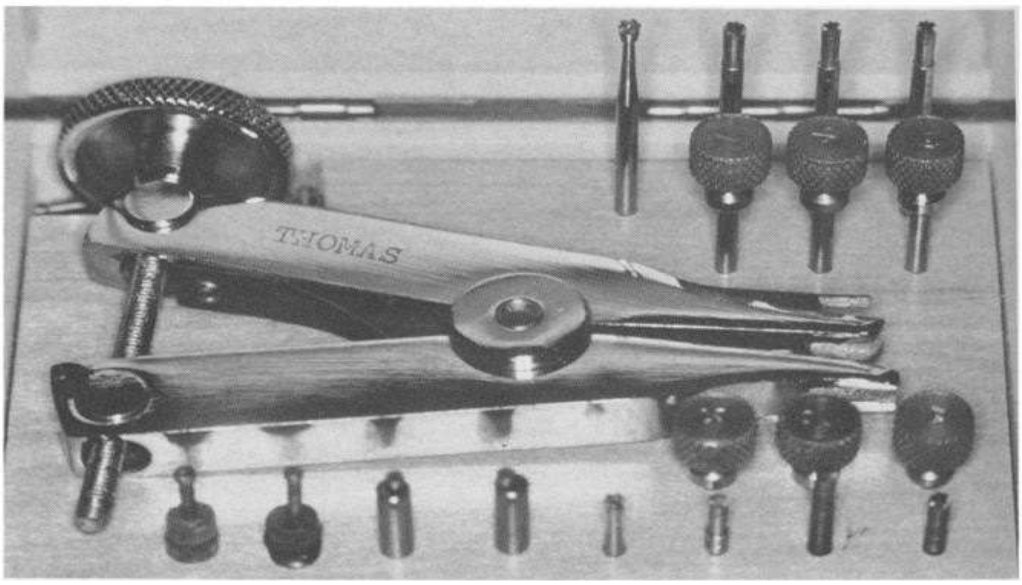


Fig. 32- The Gonon post removal system

A transmetal bur is used to round-off, chamfer or taper the coronal most aspect of the post. “Doming” the head of the post will serve to effectively guide the subsequent instruments over the post. A drop or two of chelator, such as RC Prep, Glyde or ProLube, is then placed on the head of the post to act as a lubricant to facilitate the machining process. In order to ensure circumferential milling, the largest trephine that will just engage the post is selected.

The latch-type trephines should rotate at approximately 15,000 RPM in a clockwise (CW) direction, in a slowspeed, high torque handpiece. The trephine is used with a “peck” drilling motion to maintain RPM and to keep the head of the post cooler so it does not work-harden and become more difficult to machine. The trephine is utilized to machine down a 2-3 mm length of the most coronal aspect of the exposed post . If the chosen trephine fits passively, then a sequentially smaller size trephine is selected to ensure proper circumferential milling. In some instances the configuration of the coronal most aspect of the post, such as a cast post/core, dictates the use of a transmetal bur or diamond to grind down the head of the post to create a relatively round cylinder. The trephine can then machine a precisely round cross-sectional diameter on the post (Fig. 33). Generally, the trephine used for machining the post dictates the subsequent selection of a correspondingly sized tubular tap.

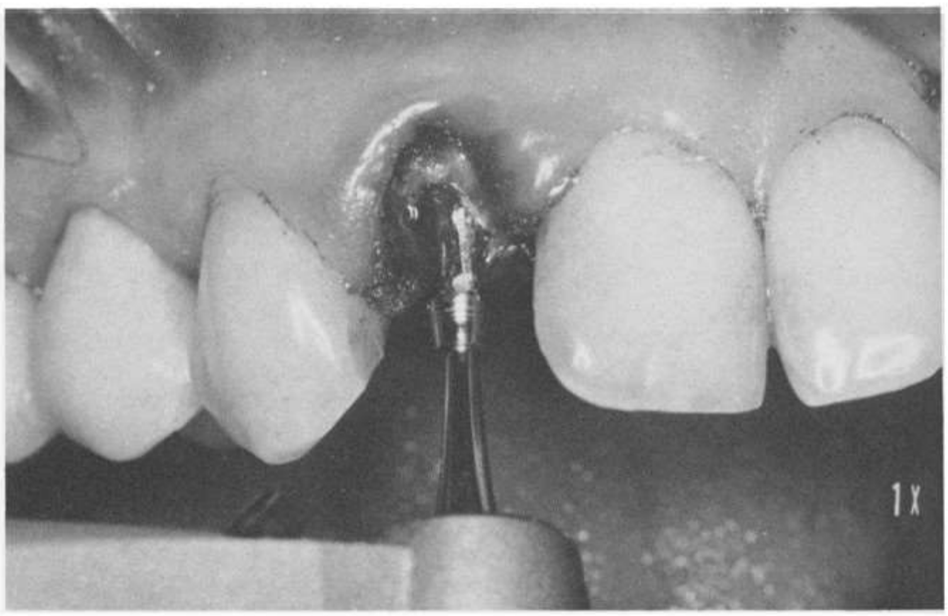


Fig. 33- Use of the trephine to remove the post

An appropriately sized rubber bumper is selected and inserted over the distal end of the tap (Fig. 34). The bumper serves to cushion, evenly distribute the loads and protect the tooth during the removal procedure. The tubular tap is pushed against the head of the milled down post and is manually turned counterclockwise (CCW) to form threads.

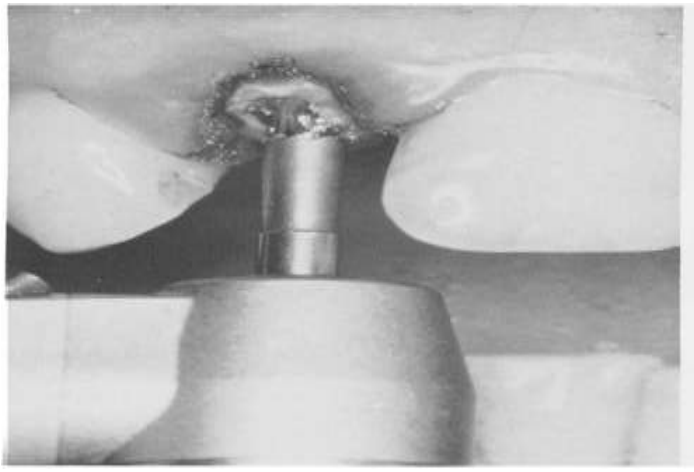


Fig. 34- Use of the tubular tap against the head of the post

Firm apical pressure and small quarter-turn CCW motions will generally draw- down and securely engage the tap to the post. The tap can be screwed over the post as little as 1 mm or, more optimally, up to a maximum of 3 mm (Fig. 35). Caution should be exercised so that the tap is not drawn down too far over the post because its maximum internal depth is 4 mm. If the tap bottoms out against the post head, it can predispose to stripping the threads, breaking the wall of the tap, or shearing off the obstruction inside the lumen of the tap. When the tubular tap has snugly engaged the post, the protective rubber bumper is pushed down onto the biting surface of the tooth.

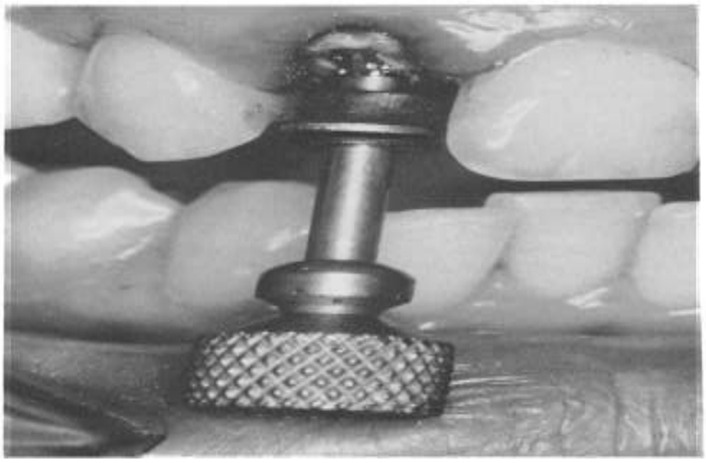


Fig. 35- Screwing the tap over the post

The post removal pliers (Fig. 36) are then selected and the extracting jaws are mounted onto the tubular tap. The instrument is held securely with one hand, while the fingers of the other hand begin opening the jaws by turning the screw knob clockwise.

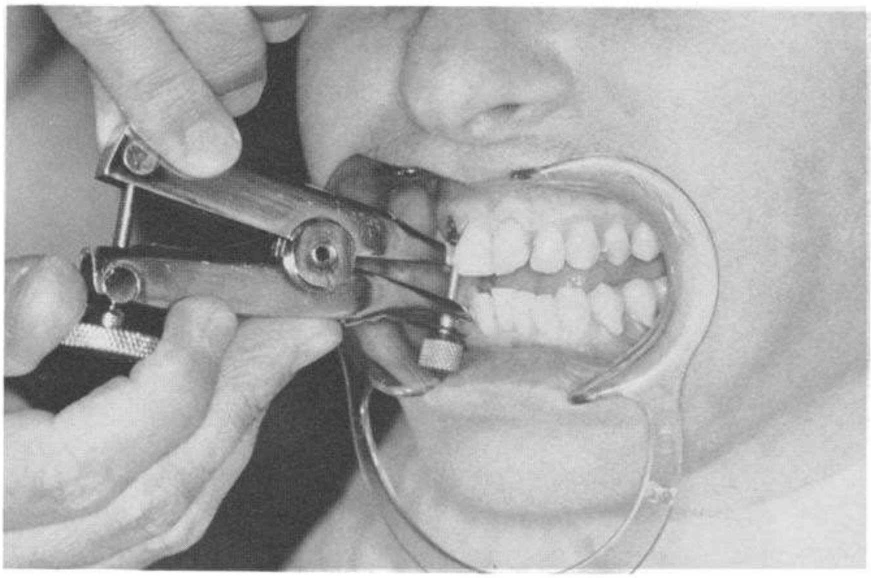


Fig. 36- Use of the post removal pliers

As the jaws slowly begin to open, increasing pressure will be noted on the screw knob. The clinician should repeatedly verify that the compressing rubber cushion is properly protecting the tooth. Further, when utilizing this removal method, the clinician should visually confirm the post is being safely withdrawn along the long axis of the root canal. If turning the screw knob becomes increasingly difficult, the clinician should either hesitate a few seconds before continuing and/or use the indirect ultrasonic technique to vibrate on the post-engaged tubular tap. In combination, the PRS and indirect ultrasonic techniques enhance post retention failure, encourage the screw knob to turn further, and are potent adjuncts to successful post removal. Ultimately, the PRS provides clinicians an important post removal method that can be safely employed when ultrasonic techniques are unsuccessful. Clinicians also encounter actively engaged threaded posts which require removal. The PRS is specifically designed to address this scenario because each tubular tap turns in a CCW rotation (Fig. 37). The post head is milled down as previously described and a tubular tap threaded until snug. In instances where threaded posts are encountered, the use of the extracting pliers is contra-indicated.

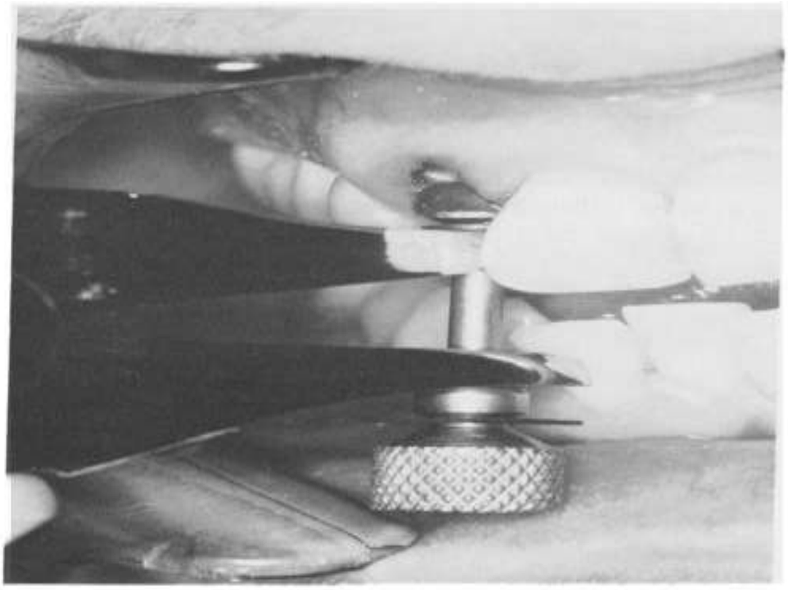


Fig. 37- Removal of a threaded post

Typically, the clinician backs the post out of the canal using a CCW rotation with finger pressure. If the post is strongly anchored, an ultrasonic instrument may be used to vibrate on the tap and, if necessary, the torque bar is inserted into the handle port to increase leverage.

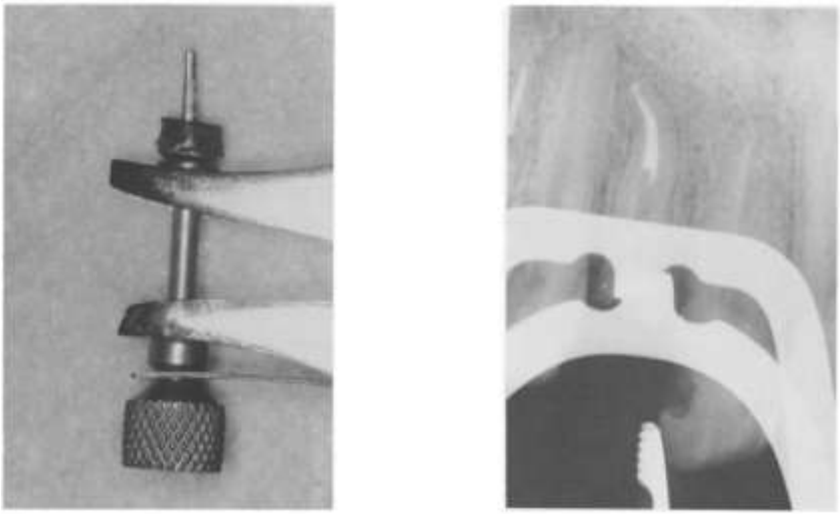


Fig. 38- Post removal in anterior teeth

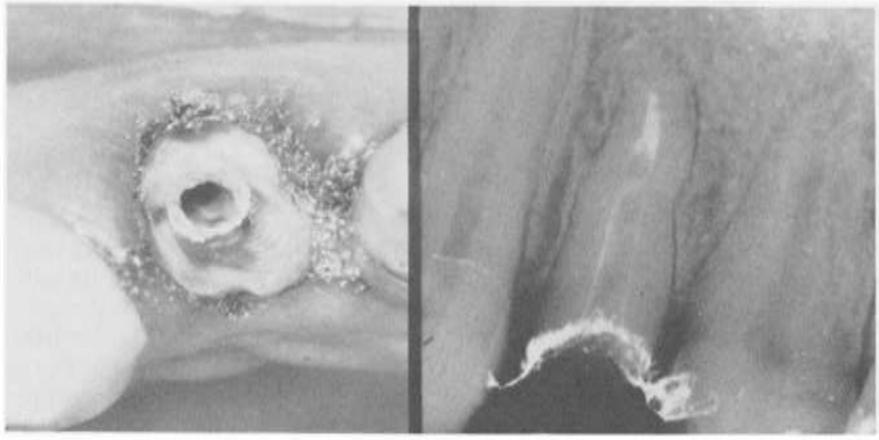


Fig. 39- After post removal

Using the PRS on Anterior Teeth

Clinicians can carefully remove posts from the roots of anterior teeth with the PRS kit. Because natural or restored anterior teeth have thin dimensions facial- lingual toward their middle and incisal one-thirds, special attention is required during post removal procedures to prevent fractures (Fig. 38, 39). If the incisal edges of the anterior teeth essentially lie on the same plane, then the post removal loads may be distributed over multiple teeth. Two or three wooden tongue depressors can be customized to lay across the incisal edges and once positioned can be stabilized with any adhesive restorative material. The extracting pliers‟ gingival arm can brace against this working platform to redistribute the total removal load from one tooth to several teeth. It should be appreciated if the post removal force is not against the root that holds the post then tooth extraction could result. Therefore, in this method of removal, it is wise to keep an eye on the tooth holding the post to ensure it is not inadvertently elevated out of its socket.

Removing plastic core material

Cores are generally constructed from amalgam or composite. The Nayyar core is advocated as a means of restoring posterior teeth without the need for posts. The material is normally packed into the coronal 3 mm of the root canals. It is very important not to try removing this material using a bur, as the risk of root perforation is high

Dismantling a Nayyar Core (Fig. 40)

Fig. 40- Nayyar Core

Using a paralleling radiograph, an estimate can be made of the depth of material to the level of the pulp floor. Using magnification, the coronal portion of the restoration is removed either with a tungsten carbide or diamond bur. The material is removed laterally until the boundaries of the pulp chamber become evident. The core material is then removed until the pulp floor just becomes visible.

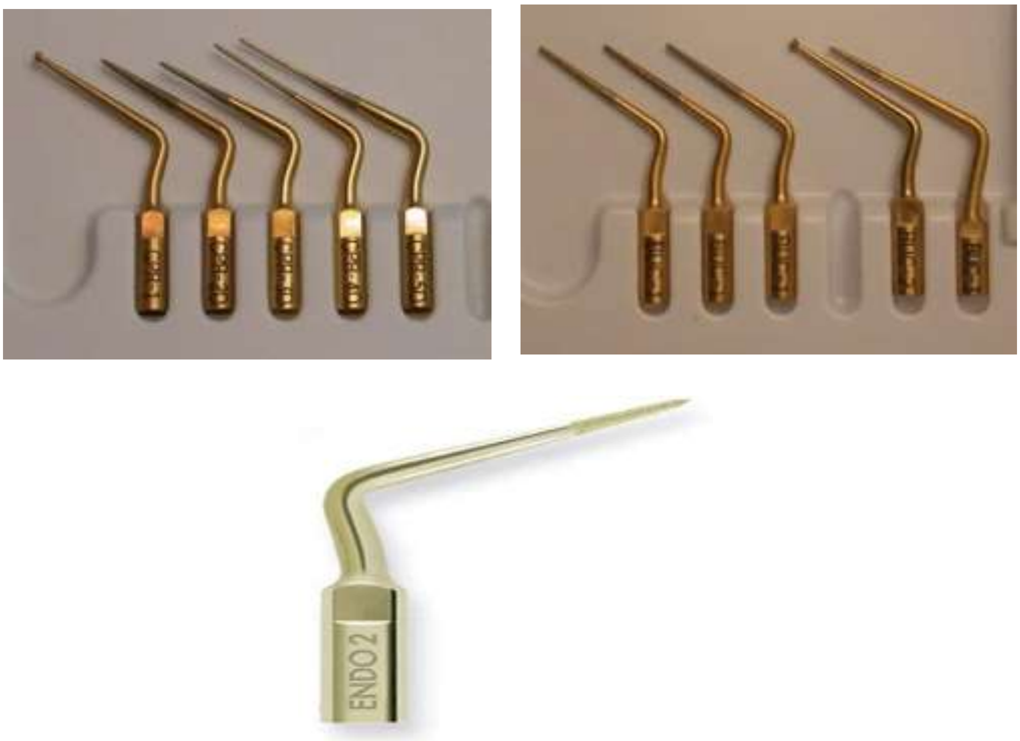


Fig. 41- Ultrasonic tips

An ultrasonic tip is then used on medium to high power with irrigant spray to carefully remove core material across the pulp floor (Fig. 41). Using the same instrument, material can be removed very conservatively from the coronal part of the root canal without risking perforation. The tips are coated with abrasive material, which aids removal of restorative materials in such a situation (1).

Removal of Fiber Posts:

- A new bur GYROTIP has been designed especially for removing fibre posts.
- Drills consists of a heat generating tip designed to soften the matrix that binds the fiber of the fiber post.
- Fluted zones allows for safely removal of the fiber.
- Above the fluted zone, plasma bonded silica carbide reduces the heat generation.

REMOVAL OF PASTES

Pastes normally have a soft consistency, but some materials can become hardened with time. Degradation as a result of bacterial activity will often result in the material becoming sludge-like in consistency (1). The various pastes that can be encountered are:

1. Zinc oxide–eugenol - More radio-opaque than gutta percha
   White/grey in color
   Hard in consistency ,becomes softer following microleakage
2. Kri paste- Radiographically white in appearance
   Yellow in color
   Soft in consistency
3. Zinc phosphate- Similar to gutta percha radiographically
   Creamy yellow/white in color
   Hard in consistency, softer following microleakage

4. Endomethasone- Similar to gutta percha radiographically
   Grey/brown/pink in color
   Soft in consistency
5. Calcium hydroxide- Similar to dentine radiographically, depending on amt of barium salts
   White in color
   Soft in consistency
6. Calcium hydroxide/ iodoform medicaments- Radiographically white in appearance
   Yellow in color
   Soft/spongy in consistency

An excellent technique for the safe removal of hard, impenetrable paste from the straightaway portion of a canal utilizes abrasively coated ultrasonic instruments in conjunction with the microscope. To remove paste apical to canal curvature, hand instruments should first be utilized to establish or confirm a safe glide path. Precurved stainless steel hand files may be inserted into this secured region of the canal and when attached to a “file adapter”, may be activated utilizing ultrasonic energy (54). The majority of soft material can easily be removed during mechanical preparation. Material deeper in the canal and within lateral anatomy can be removed using endosonic irrigation. The vibrating file tip loosens the paste, which is flushed away by irrigant activated by acoustic microstreaming (1). Other removal methods include heat, judicious use of end-cutting rotary NiTi instruments and small sized hand files with solvents such as Endosolv R and Endosolv E. Additionally, Micro-Debriders and paper points in conjunction with solvents play an important role in removing paste from canal irregularities (54). Solvents include chloroform, Endosolv R and Endosolv E (Fig. 42). Endosolv R is designed for the removal of phenolic resins, whereas Endosolv E is formulated for the removal of eugenol-based cements.

Fig. 42- Chloroform, Endosolve R and Endosolve E

Removal of calcium hydroxide, is highly recommended and widely accepted as an interappointment intracanal endodontic dressing because it demonstrates a pronounced antibacterial activity against most of the bacterial species identified in endodontic infections. Calcium hydroxide removal before final obturation is routinely accomplished by either sodium hypochlorite (NaOCl) or saline and/or instrumentation in a reaming motion with a small endodontic instrument, or with the master apical file 17. The consensus of opinion suggests that flushing the canal alternately with 17% EDTA and sodium hypochlorite is probably the most effective method 1. Residual calcium hydroxide left intracanally has been shown to interact with zinc oxide-eugenol-based sealers substituting the zinc oxide- eugenol chelate formation for calcium eugenolate. The short-term clinical implications are a rapid setting reaction of the sealer that block gutta-percha entrance and placement to full working length. Treatment with EDTA neutralizes calcium hydroxide residues: but, if residues are not removed, they may interfere with the sealing efficiency from a mechanical point of view. The calcium hydroxide packed apically during the removal procedure or in lacunae, regardless of the removal method used, could be of significance for the outcome of the root canal treatment. Although an apical plug with calcium hydroxide has been advocated, it is preferable to remove it because it might enhance apical microleakage and jeopardize the outcome of treatment. In addition to mechanical and chemical cleansing of the root canal, perhaps a patency to file # 10 or even file # 15 should be used 17. Modern nickel–titanium instruments are excellent in this respect as the medicament is retrieved and carted coronally when the instrument advances into the canal. Little of the dressing material should be extruded, but any that is will normally be absorbed. A solvent is required to remove the remaining material from within the root canal, and chloroform appears to be effective. This is introduced into the canal in small increments and paper points are used to wick the dissolved material. The process is repeated until the points no longer appear yellow when removed from the canals (1).

Removal of Gutta Percha

Gutta-percha in combination with a sealer is the most frequently used material. Techniques described for gutta-percha removal include the use of rotary instruments, heat carrying instruments and solvents. In many cases the combined use of different techniques may be the most efficient and time-saving method. The use of Hedstrom files without any other methods of removal is more time consuming than other techniques but results in better cleanliness compared with hand instrumentation and the use of a solvent according to Wilcox. The use of chloroform as a solvent for gutta-percha is controversial. It has been reported to be locally toxic when contacting periradicular tissues. Additionally it is hepatotoxic and nephrotoxic and is classified as a carcinogen. According to McDonald & Vire (1992) and Allard & Andersson (1992) there seem to be no or only low risks of occupational hazards for the patients and the dental team when the solvent is stored in a closed dappen dish. Several different solvents, among them halothane, eucalyptol, xylol, methyl chloroform, tetrahydrofuran, methylene chloride and others have been recommended as alternatives to chloroform for gutta-percha retreatment cases. Chloroform has been shown to be the most effective gutta- percha solvent when compared to most of these solvents (Fig. 42). Reduction in time is seen when Hedstrom files are used with a solvent compared to the use of Hedstrom files alone, but rotary devices prove to be significantly faster. On the other hand root canal cleanliness is seen to be less satisfactory. This may be a result of the softening procedure with the softened gutta-percha „smeared" over the root canal walls. Solvent should not be used in the apical part of the root canal to prevent contact with the periradicular tissues (2).

Due to the potential carcinogenicity of chloroform other solvents, such as halothane and turpentine, have been suggested and successfully utilized for the same purpose. Halothane is, less effective than chloroform in dissolving gutta- percha, and it has the same level of toxicity as chloroform. The hepatotoxicity of halothane has also been reported and thus, it does not seem to be a very good substitute for chloroform. Turpentine has showed higher toxicity than chloroform and halothane. Allergy to turpentine and systemic alterations have also been seen. However, turpentine has been shown to be noncarcinogenic and suggested to be biocompatible (13).

Removal of GguttaPercha using rotary system

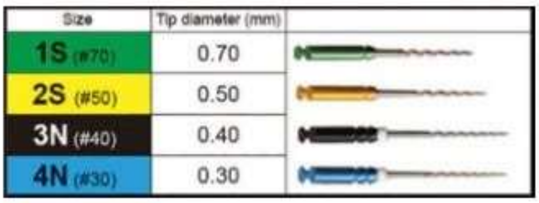
Attempting to remove GP, it is wise to divide the canal into thirds and to use appropriate size instruments. To soften and to engage GP the rotary instrument should turn at a speed ranging from 1200-1500 RPM.

- Protaper universal retreatment files (by dentsply).

• Mtwo R (size/taper-R15/0.05,R25/0.05)

• Recioroc (VDW) - this was created by Dr.GassenYard,offers greater flexibility and resistance to cyclic fatigue that traditional niti files.

• The Mani GPR system is a 4-file system that is configured into an assorted pack of 4 instruments (1S, 2S, 3N, 4N) and 4 individual sizes, again, 1S, 2S, 3N, and 4N sizes. The 1 and 2 "S" instruments are stainless steel, and the 3 and 4 "N" instruments are nickel titanium



Size	Tip diameter (mm)	
1S (#70)	0.70	
2S (#50)	0.50	
3N (#40)	0.40	
4N (#30)	0.30	

Figure 1: Mani GPR files, the Assorted Pack 1S, 2S, 3N, 4N

• HyFlex® NT™ endodontic rotary NiTi file is designed to work in specific clinical situations, such as calcified canals, straight canals, retreatments and removing Gutta- percha. HyFlex® NT™ files are available in .06 and .04 tapers in 21mm, 25mm and 31mm lengths

• Neoendo Retreatment Files comes as N1 - For Coronal one-third, N2 - For Middle one-third and N3 - For Apical one-third. N1 and N2 comes in 16mm and 18mm and N3 comes in 22mm and 25mm. Retreatment Files are used with gentle touch, the files are never forced and always the recommended speed and torque setting is used.

• Endostar RE Re Endo Rotary System is used for removal of old gutta-percha filling from the root canal system. Endostar RE Re Endo Rotary System set consists of 4 instruments of different sizes and tapers marked with numbers from 1 to 4.

Soft tissue lasers:

Studies conducted on the effectiveness of Nd;YAG laser for the removal of gutta-percha have shown that it is capable of softening gutta-percha

- Lower setting: (100MJ, 15Hz, 1.5w)

Fairly clean root canals but incomplete elimination of guttapercha from dentinal walls.

- Increased power levels: (100MJ 20Hz, 2w)

More effective on the canal walls for cleaning

Specially designed gutta percha removal instruments

Gates Glidden drills and long neck burs are limited by the depth to which they may be used in the canal-in particular, a curved root, where they have to be confined to the straight part of the canal. Gutta percha removal instruments are more effective than Gates Glidden drill or long-neck burs. When operated in a root canal, the frictional heat generated softens the gutta percha which is evacuated coronally by the cutting flutes, operating in an Archimedian screw principle. There is always a risk of fracture when using gutta percha removal instruments. As a result, great care must be exercised, avoiding excessive force and too high a rotational speed. All these instruments may facilitate removal of most of the root filling - however, some gutta percha remnants are inevitable and its removal requires the use of a solvent.

REMOVAL OF HARD CEMENTS

There are several hard cements that could be encountered during root canal retreatment. Hard materials are one of the most challenging to remove from the root canal system, as there is an increased risk of damaging the tooth. Set cement will probably have to be removed by mechanical means using burs or ultrasonic tips. Sometimes a solvent may be available if the material can be identified. When the root filling has been poorly placed or microbial leakage has undermined a material, there may be voids created along the canal wall interface that will allow the introduction of instruments and consequently aid removal. Good illumination and magnification, preferably with a microscope, will allow the operator to distinguish between the filling material and the root canal wall. This should reduce the risk of perforation. Tungsten carbide burs can be used to remove material from the most coronal part of the root canal. Diamond coated ultrasonic tips used in a Piezon-type ultrasonic machine are particularly useful.

These can be used with or without waterspray but, when used dry, the assistant will need to puff air from a 3:1 syringe onto the field to clear dust particles for aspiration. Occasionally, chips may prevent a clear view of the interface between material and root wall. In this instance irrigation with EDTA for 2 minutes followed by air drying will usually clear the microscopic field. The Stropko irrigator (Fig. 43) is a useful addition to the armamentarium when working with a microscope and allows easy drying of the operating field when working at higher magnifications

Fig. 43- The Stropko irrigator

Solvents for set cements are notoriously slowacting, and removal using this method can be extremely laborious and time-consuming.

Solvent is applied to the material and allowed to react. An endodontic instrument is used to remove any softened material. The solvent is replenished and the process repeated. Endosolv R is designed for the removal of phenolic resins, whereas Endosolv E is formulated for the removal of eugenol-based cements (Fig. 42). Chloroform may also be useful for some types of set cement. Resorcinol– formalin-based materials are notoriously difficult to remove, and even solvents may prove inefficient. The manufacturers of Endosolv R recommend that the solvent is sealed into the root canal orifice for several days, during which the cement should soften. Dimethyl sulfoxide has been suggested for removal of this material (1).

REMOVAL OF SILVER POINTS

Rigid core root filling materials including silver points were once in vogue but are no longer regarded as satisfactory as they do not seal root canals completely. For this reason, they are often seen in cases presenting for retreatment. Silver points are made of relatively soft silver alloys containing 0.1-0.2% of copper and nickel.

When removing silver points, it should also be remembered that their corrosion products are toxic . Copious irrigation must therefore be used and great care exercised to ensure corrosion products are not pushed out of the apex as this may provoke undesirable acute consequences. Silver point corrosion products may also cause gingival tattooing.

A silver point can usually be removed successfully if it is:

· visible and accessible
· loose
· possible to gain purchase.

Visible and Accessible

Great care must be taken so as not to cut off the coronal end of the silver point, which extends into the pulp chamber. Material surrounding the silver point is best removed gently with an ultrasonic scaler, taking care to avoid touching the silver point directly with the scaler to prevent weakening or breaking off its coronal end. If embedded in amalgam, the coronal ends of silver points may be especially difficult to find; the amalgam should be sectioned carefully with a bur and then removed using ultrasound.

Loose

If the silver point is wedged tightly, it needs to be loosened by removing whatever is encasing it. Dentine, cement or filling material around the coronal portion of the silver point can again be safely removed using ultrasound. Hand, rotary, ultrasonic or sonic files may then be inserted and worked circumferentially to loosen the silver point within the canal. Silver points inserted with resin based sealers - for example, AH 26 - are very resistant to removal because it is difficult to break the cement lute. A gutta percha solvent may help, but some sealers are very resistant to dissolution. An overextended silver point, wedged in the apical foramen is particularly challenging to remove ; if all else fails, surgery may be required.

Possible to Gain Purchase

Once loosened and when sufficient length has been uncovered, the coronal end may be grasped and the silver point extracted using a variety of instruments including:

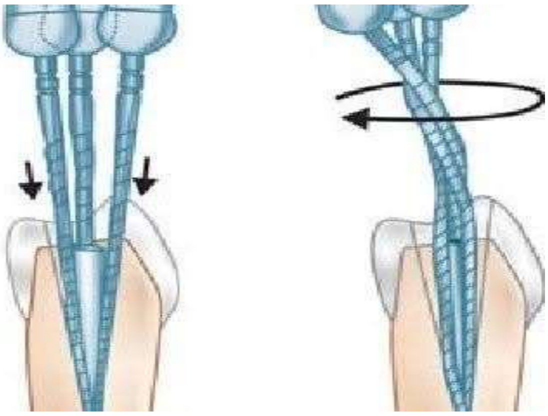
. Tweezers
· A fine-beaked haemostat
· Steiglitz forceps
· Levered out using a spoon excavator or Caulfield silver point retriever

If the exposed coronal end is too short or impossible to grab hold of, then removal may be attempted using one of the following:

· **Hedstrom file -** if there is plenty of space alongside the silver point, a Hedstrom file may be used to engage and extract the silver point. The cutting flutes of the Hedstrom file are particularly effective for this purpose.

Braiding technique

- Three small (e.g. ISO size 15) Hedstrom files are first worked alongside the silver point. With the files inserted, they are twisted and braided around the silver point to engage it. The silver point is removed when the files are withdrawn together. However, this method of silver point removal is only successful provided there is sufficient space adjacent to the silver point to place multiple files. If incorrectly applied there is the risk of breaking files inside the root canal, compounding the problem.



Masserann extractor

- consists of a hollow tube with a constriction, which is placed over the coronal end of the silver point. A stylet is then inserted into the hollow tube to trap the silver point against the constriction - a minimum of 3mm is needed for effective purchase. When the extractor is removed, the silver point is then pulled out.

Meitrac Endo Safety System

- The Meitrac II is designed for silver point removal. It consists of a trepan (0.21 mm diameter) and two extractors (0.7 or 0.9 mm diameter). The trepan may be used to create a trough around the top of the silver point and an extractor, which is spring-loaded, is then chosen to engage and remove the silver point. Again, a minimum of 3 mm is needed for effective purchase.

· Ultrasound and sonic devices - an ISO size 15 ultrasonically or sonically- energised file, combined with high-volume irrigation, may be used to float out a silver point, Provided the silver point is of a relatively small size and loose, this technique may be effective.

Cancellier extractor - these extractors are a set of hollow tubes, which fit into a handle; the assembly resembling a hollow plugger. The appropriate size extractor is chosen to fit closely over the silver point. A drop of cyanoacrylate glue is placed into the hollow end of the extractor so that it adheres when fitted over the silver point. A drop of acrylic monomer liquid can then be used to accelerate the setting of the cyanoacrylate glue and the silver point is retrieved when the extractor is removed. The Cancellier extractors can be cleaned with a solvent, e.g. xylene (xylol) and reused.

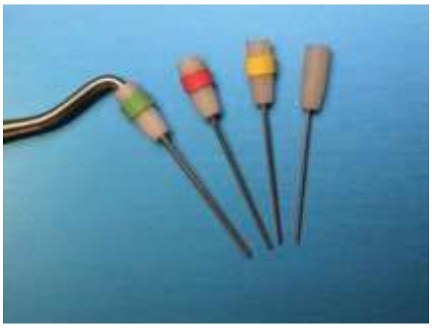


Fig. 44- Endo Eze tips

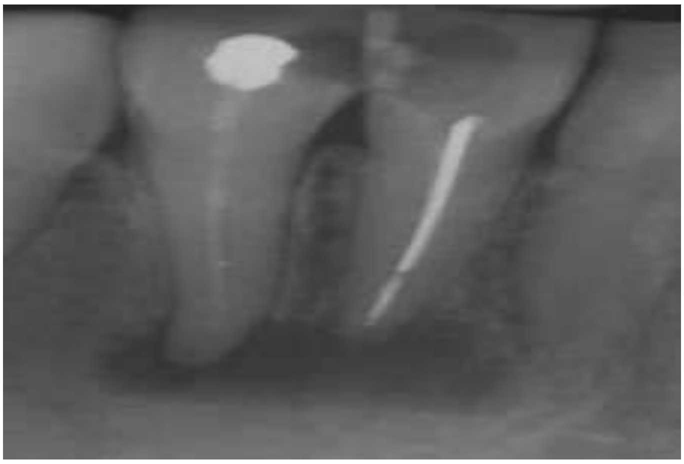
In a less sophisticated version of this technique, a blunt periodontal irrigating needle or an appropriate size Endo-Eze tip (Fig. 44) may be used as a substitute for a Cancellier extractor, together with the cyanoacrylate glue. There is no danger of accidental bonding to tooth tissue with this adhesive technique so practitioners should not worry. The worst that can happen is that the silver point resists removal.

Fig. 45- Removal of a silver point

Sectional Silver Points

Sectional silver points are very difficult to remove. Provided there is good lighting, visibility and access, removal may be attempted (Fig. 45, 46). The approach is still to gain access and loosen the silver point. Specially designed, long reach tips allow the application of ultrasound to whatever is encasing the sectional silver point. A trough may also be made around the coronal end to uncover the sectional silver point. Alternatively, a file or a Masserann extractor may be used to engage the sectional silver point and ultrasonic vibrations from a scaler can be transmitted indirectly. The loosened silver point can then be vibrated or floated out using an irrigated ultrasonically activated file.

Fig. 46- A Sectional Silver point



Stage 1: Expose the coronal end

A "staging platform" is made at the coronal end of the retained instrument, with a Gates-Glidden "belly" bur, modified by flattening off its guiding tip. NiTi coronal flaring rotary instruments may also be similarly modified and used.

Dentine around the top of the retained instrument is carefully removed, creating a trough. This may be achieved using:

· A small round bur
· A Meitrac or Masserann trepan
· Ultrasound, preferably

Stage 2: Loosen the instrument

The instrument lodged in the root canal must first be loosened. This may be achieved with small hand or rotary files and a gel-form chelating agent to lubricate the file and soften the dentine. If the obstruction is a small fragment of an instrument, ultrasonic or sonic vibrations may be used to try and loosen and eventually float it out.

Stage 3: Engage the instrument

Once a sufficient length of the instrument has been uncovered, it can then be engaged and removed using:

Hedstrom files
Steiglitz forceps
Masserann or Meitrac extractors

Others devices - Cancellier extractor and Ruddle iRS (instrument removal system).

It consists of a hollow tube with a side cut out. The tube is placed over the fragment of instrument. A style is then inserted into the hollow tube to engage the instrument, which is removed when the assembly is withdrawn.

Unfortunately, there are frustrating practical limits to these methods of instrument removal. For example, even the finest-beaked Steiglitz forceps are often unable to reach deep enough to grasp a retained instrument, or an inadequate length of instrument can be exposed or available coronally to allow secure engagement of a Masserann or Meitrac extractor.

If Not Retrievable

If retrieval is impossible or too risky, the next best scenario is to bypass and incorporate the retained instrument into the new root filling. Stainless steel and NiTi instruments will not corrode if left inside a root canal. They are, therefore, relatively harmless in themselves; it is the infected canal apical to the obstruction that is the problem. The technique for bypassing a retained instrument is the same as that for managing a blockage or ledge.

If it is impossible to retrieve or bypass, then there is no alternativc but to leave the broken instrument inside the root canal and retreat the tooth to the level of the obstruction. Sometimes, it may be possible for irrigants and medicaments to penetrate past the broken instrument so the canal should be soaked with copious amounts of sodium hypochlorite and dressed to help reduce the intracanal microbial load before inserting the root filling.

After completion of non-surgical retreatment, the tooth should be restored with a long-term temporary restoration and put on probation, for up to a year initially, to see if the symptoms resolve and healing occurs . If not, follow-up treatment, possibly surgery, may be required. With careful case selection the success rate of retreatment of teeth with retained instruments may not be significantly reduced.

REMOVING SEPARATED INSTRUMENTS

The degree of difficulty when retrieving a separated instrument will depend on the position of the object within the root canal system. Favourable factors for the removal of separated nickel–titanium fragments have been reported to be:

● Straight root canals
● Anterior teeth
● Localization before the curvature in the coronal or mesial third of the root canal
● Fragments longer than 5 mm
● Hand, as opposed to rotary, instruments. Ideally, any broken instrument that can be visualized with the operating microscope should be removed, and many techniques have been described. Fragments that are close to the foramen, protruding beyond it, or hidden from view may require a surgical approach if removal is required. It is important to explain to the patient that a broken instrument itself is not a direct cause of treatment failure. Apatient"s symptoms or a radiolucency may have persisted because the object has prevented adequate disinfection or elimination of bacteria. Therefore, during retreatment the operator should aim to remove the separated instrument so that the root canal can be thoroughly cleaned and shaped. If this is not possible, then the instrument may be bypassed to allow access to the portion of the root canal that has not been disinfected. Hedstroem files can be very retentive when broken in root canals, as the blades of the file engage with the dentine of the root canal

walls. Spiral fillers can act like a spring and become wedged in the root canal. Pulling a spiral filler in an attempt to retrieve it before adequate loosening can often just result in unwinding of the instrument.

Nickel–titanium instruments can become firmly wedged as the instrument attempts to straighten within a curvature in the root canal and this can make retrieval more difficult. If possible, an assessment of the microbial status of the root canal at the time of the accident is of importance. During treatment of a vital pulp, instrument fracture may be of lesser consequence. There should be little evidence of microbial infection, and therefore the long term prognosis despite instrument failure should be reasonable. On the other hand, when a tooth has an obvious periapical radiolucency associated with it and the root canal is undoubtedly infected, separation of an instrument early in the preparation sequence may result in the root canal being inadequately cleaned. This is no basis for a predictable outcome. After all, the instrument is not going to provide an effective seal, and the root canal will remain infected.

Retrieval of Stainless Steel Instruments

If an instrument has fractured coronally and can be bypassed, a small file is first introduced along side it. Endosonics can then be used to loosen the instrument within the root canal.

Fig. 47- Retrieval of Stainless Steel Instruments

If the instrument has fractured below orifice level, the access and root canal preparation may have to be modified to allow retrieval. Straight-line access is fundamental and allows the creation of an exit pathway for the fractured instrument: in other words, there should be no obstructions to the removal of the instrument. The access can be modified using a non end- cutting tungsten carbide bur such as the Endo-Z or an LA Axxess bur. The latter is a long-shank diamond bur with a non-cutting but pointed tip. This can be inserted into the orifice of a canal and allows lateral refinement of the access cavity wall. Diamond-coated ultrasonic tips are also useful for refining the access. A Gates–Glidden bur can be modified by removing the safe ended tip. This creates an extremely efficient instrument that will cut a platform over the coronal end of the fractured instrument. Under the operating microscope, space may be visible alongside the instrument into which a small file can be introduced to bypass it. Following this, endosonics are used to try to loosen the fragment and retrieve it. If it does not dislodge, a fine ultrasonic tip can be used to trough around the head of the instrument. Copious irrigation will be required. Packed dentine chips can be removed using a chelating agent such as 17% EDTA.

The Instrument Removal System

The instrument removal system (IRS) (Dentsply-Maillefer, Ballaigues, Switzerland) is an excellent means of attempting to retrieve the loosened object. This device consists of a hollow tube with a lateral window at the tip (Fig. 48).

Fig. 48- The Instrument Removal system

A rod is inserted into the tube and the object that is to be removed becomes trapped as the screw is tightened. When engaged, a careful watch-winding action is used to help loosen the instrument and retrieve it from the root canal.

REMOVAL OF NICKEL–TITANIUM INSTRUMENTS

Nickel–titanium (NiTi) alloys tend to be brittle and removing them with ultrasonics can be frustrating. If the ultrasonic tip touches the head of the fractured file, it will bury itself deeper into the root canal. Excessive use of ultrasonic vibration can result in further fracture of the separated instrument, resulting in an even more difficult retrieval situation. There are four phases in the retrieval of a fractured nickel–titanium instrument:

- Modification of access
- The creation of an adequate exit pathway
- Loosening of the instrument
- Retrieval.

Modification of the Access Cavity

A common reason for failure of nickel–titanium rotary instruments is inadequate access preparation. Placement of the access cavity in the incorrect position or making it too small puts unnecessary stress on the instrument as it is rotated in the root canal. The instrument then fails as a result of cyclical fatigue. At the other extreme, too large an access unnecessarily weakens the tooth and may make it more difficult to restore. When attempting to remove a fractured instrument from a curved canal, any primary curvatures or constrictions need to be removed. This will allow the creation of direct access to the coronal part of the instrument and hence a straight-line exit pathway for retrieval.

The Exit Pathway

Direct access is created in the root canal coronal to the fractured instrument to allow an unimpeded exit. Modified Gates–Glidden burs are probably the most efficient means of achieving this (Fig. 49). This has been described as the creation of a staging platform that allows the use of ultrasonic tips under direct vision with a microscope.

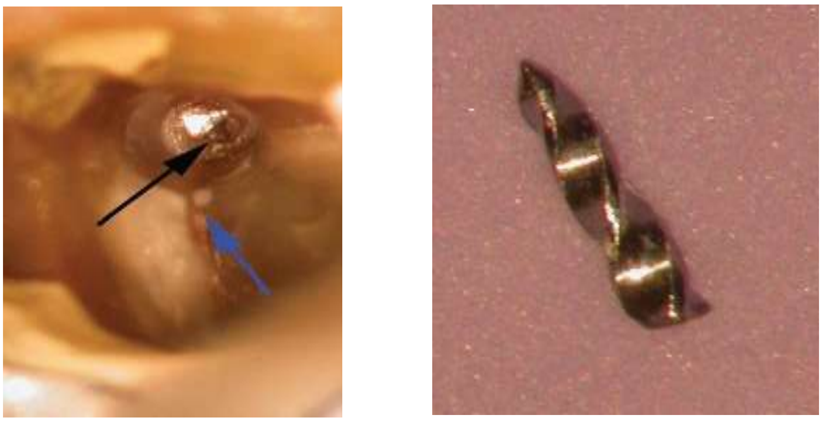


Fig. 49- Removal of the separated instrument

Loosening

Being careful to avoid intimate contact with the head of the fractured instrument, a fine ultrasonic tip such as CPR 6, 7 or 8 can be used to trough around it, creating space.

Light pressure can then be applied to the lateral aspect of the fractured instrument with the ultrasonic tip. This will sometimes encourage the rotary file to unscrew. Sometimes space may be limited, and even the finest ultrasonic tip will prove to be too large or obscure the view in the operating microscope. In this situation, an endosonic file can be modified to produce a very fine but relatively robust instrument. The apical 6 mm of an ISO size 15 endosonic file is removed with a pair of scissors, producing an extremely fine micro-instrument that can also be pre-bent to allow better visualization deep in the root canal. It is an efficient tool but should only be used when operating with a microscope. Any stainless steel file can be used in this way. Most nickel–titanium rotary instruments have a cross section consisting of flutes and blades. With direct vision under the operating microscope, the endosonic file, activated at low power, is first placed in the flutes to selectively remove dentine alongside the brokeninstrument. If this fails to result in any loosening of the fractured instrument, the endosonic file can be used to trough carefully around the head. Following this, lateral placement of the endosonic file against the fractured nickel–titanium instrument is used to help loosen the instrument. Copious irrigation with EDTA is used to clear debris after each short burst of ultrasound. If the instrument cannot be retrieved by ultrasonics alone, a removal system will be required. The IRS is probably one of the most efficient means of retrieving an instrument in this situation. Extractors such as the Masserann or Meitrac are often too cumbersome for use in intricate root canals. Often, the separated instrument cannot easily be retrieved because it is flexing within the curved root canal and pressing against the outer wall. The tube of an IRS extractor has a bevelled tip and this can be very helpful to scoop the flexed nickel–titanium fragment into it. Engaging the rod and screwing both halves together will grip the instrument. Careful watch-winding and anti-clockwise rotation should then result in retrieval.

Bypassing

If it is not possible to retrieve an instrument or the operator feels that the risk of perforation or irreversible damage is too great, then bypassing should be attempted. In this way, the root canal beyond the fractured instrument can be cleaned in the normal manner and the fractured instrument is incorporated in the root canal filling. The technique for bypassing an instrument is similar to that for retrieving silver cones or fractured instruments.

Retaining the Fractured Instrument

If it proves impossible to retrieve or bypass the instrument, there is no alternative but to leave it within the root canal system. The root filling is completed to the most coronal part of the fractured object and the canal obturated. A review is carried out in the normal manner and, if symptoms fail to resolve, then an alternative treatment approach may be required. In teeth without periapical radiolucency, this should not appear to affect the prognosis (1).

RENEGOTIATING THE ROOT CANAL FOLLOWING DISMANTLING

Irritation dentine, pulp stones and other calcifications may make the location of root canal orifices or negotiation of a root canal difficult. Exposing the Canal Orifices Microscopic magnification and illumination combined with ultrasonic tips are invaluable in this situation and provide the most predictable means of locating canal orifices. Ultrasonics allow the precise removal of dentine from the pulp floor with minimal risk of perforation. Ultrasonic diamond-coated tips can be used dry in intermittent bursts to remove dentine. The assistant uses a Stropko irrigator to puff away dentine chips. A solution of 17% EDTA is excellent for clearing the area under exploration. The pulp chamber should be flooded with EDTA solution for 2 minutes. Dentine chips and other debris can then be washed away with sodium hypochlorite. The pulp floor is explored with a DG16 probe or micro- debrider to locate the canal orifices. If the canal is very fine, highly curved or sclerosed, then a fine hand instrument such as a C file can be used to gauge a pathway A thorough knowledge of the anatomy of the pulp floor and the likely location of the canal orifices is essential. The pulp floor map and the relationship of the floor to surrounding tooth structure should give some idea of the location of root canals. The pulp floor tends to be darker than the walls. Dyes, such as iodine in potassium iodide or methylene blue, have been used to demonstrate the location of canal orifices. The orifices tend to be located at an imaginary point directly apical to the original location of the cusp tip. Dentine needs to be removed very carefully when attempting to locate sclerosed canals. Ultrasonic tips such as the CPR 2 and 3 allow precise removal of dentine from the floor of the pulp chamber. Swan-necked LN burs can also be very useful. If the canal is completely sclerosed for several millimetres apical to the pulp floor, instruments should be advanced gradually and a confirmatory radiograph exposed to ascertain orientation of the instrument within the canal. Under the microscope, it is often possible to distinguish between irritation dentine occluding the original canal and that of the root wall. The area that needs to be removed tends to be darker.

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Achieving Patency

Patency of the root canal can be lost if dentine chips are compacted into the apical part of the root canal system during preparation.This is more likely to occur if insufficient irrigant is used during preparation. There are benefits in achieving patency in infected root canals to ensure efficient distribution of irrigant into lateral canals and apical deltas. However, the benefit of patency has been questioned in cases where preventative retreatment is being carried out (1).

CONVENTIONAL VS SURGICAL RE-TREATMENT

When a decision between a conventional and a surgical re-treatment needs to be made, clinicians should evaluate whether the existing condition necessitates damaging a successful restoration to gain orthograde access to the root canal system and if the restoration is intact or can be removed at all. Disassembly may not be reasonably safe and could lead to a nonrestorable situation. In some cases, it might be better to either access the root canal system through the restoration or more conservatively to consider surgical re-treatment. However, if a restoration is lost or coronal leakage exists, the restoration should be removed to clean out all sources of infection and to prevent a possible route of entry for bacteria into the root canal system. It is key to consider conventional re-treatment first in the case of existing leakage (Fig. 50).

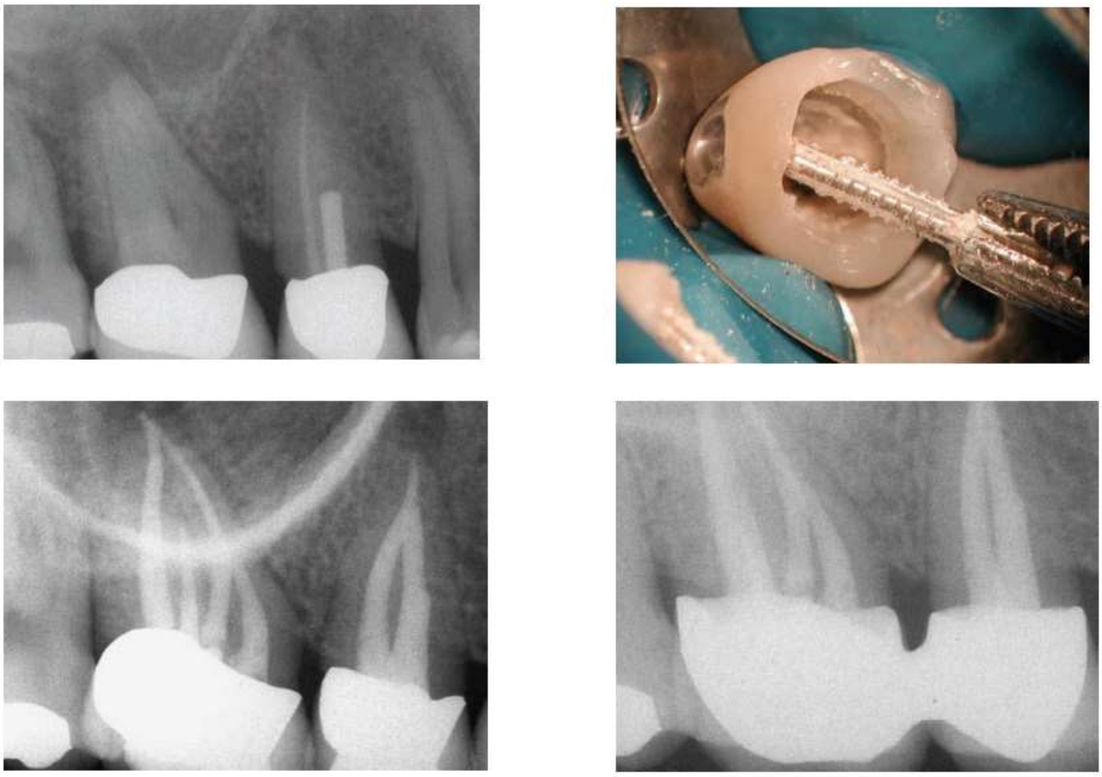

Fig. 50- Conservative re-treatment

The quality of the obturation should be evaluated radiographically before treatment. It is recommended to take multiple angulation radiographs to get maximum information on the root morphology and the previous treatment. The filling material may look dense or show voids. There may be signs of perforations, ledges, separated instruments, infected lateral canals, or internal or external resorption. The location of perforations can dictate the suggested treatment. Zipping or perforations at the apical level more likely cannot be repaired from inside the root canal system. If there are separated instruments or foreign objects, their location within the canal system dictates whether to retrieve or bypass the instrument. If a separated object is beyond the canal curvature (Fig. 51), conventional removal is not advised, but a surgical approach is preferred.

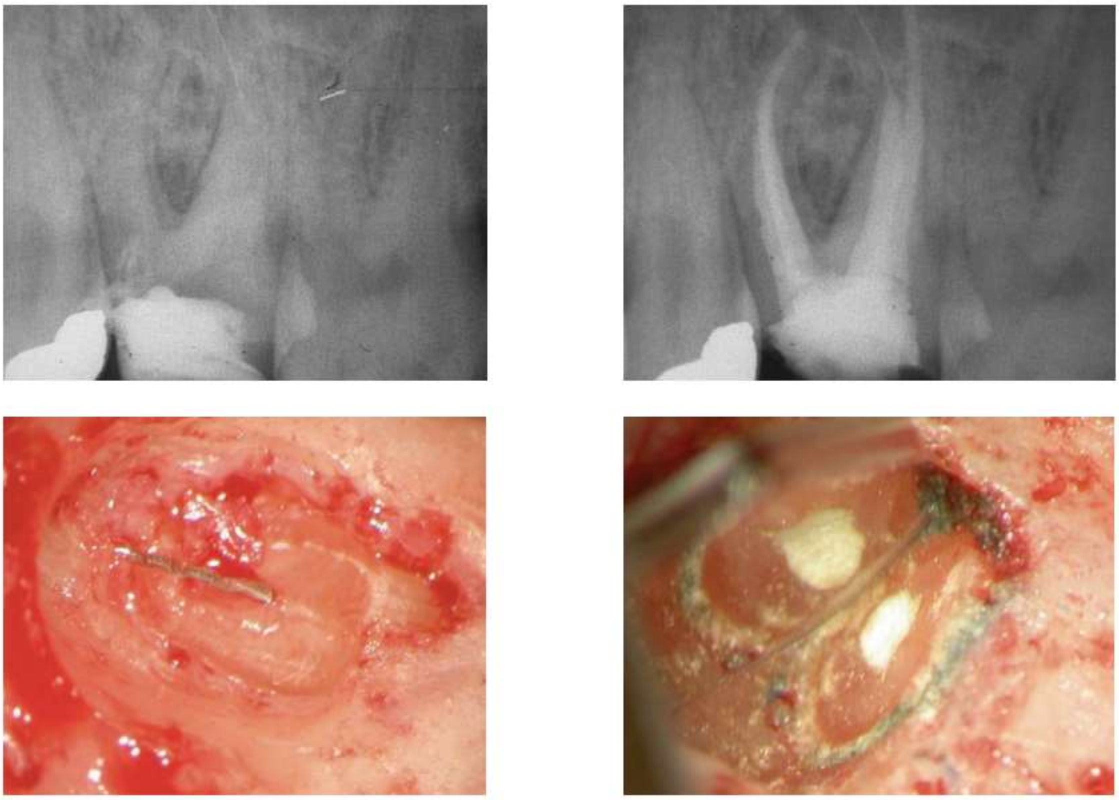

Fig. 51- Removal of a separated instrument beyond the root canal curvature

Surgically

The apical extension of the filling can appear too short or too long. When an overfilling is obvious, surgical treatment is often the successful approach if the condition of the root canal treatment cannot be significantly improved by conventional re-treatment. The suggested working length for teeth with periapical lesions is 1 mm from the radiographic apex, with the obturation material confined to the root canal space. Ending at or short of the apical constriction results in the most favorable histological condition. If patency cannot be achieved or transportations or ledges are present, the chances to clean out infection properly are minimized 55 (Fig. 52).

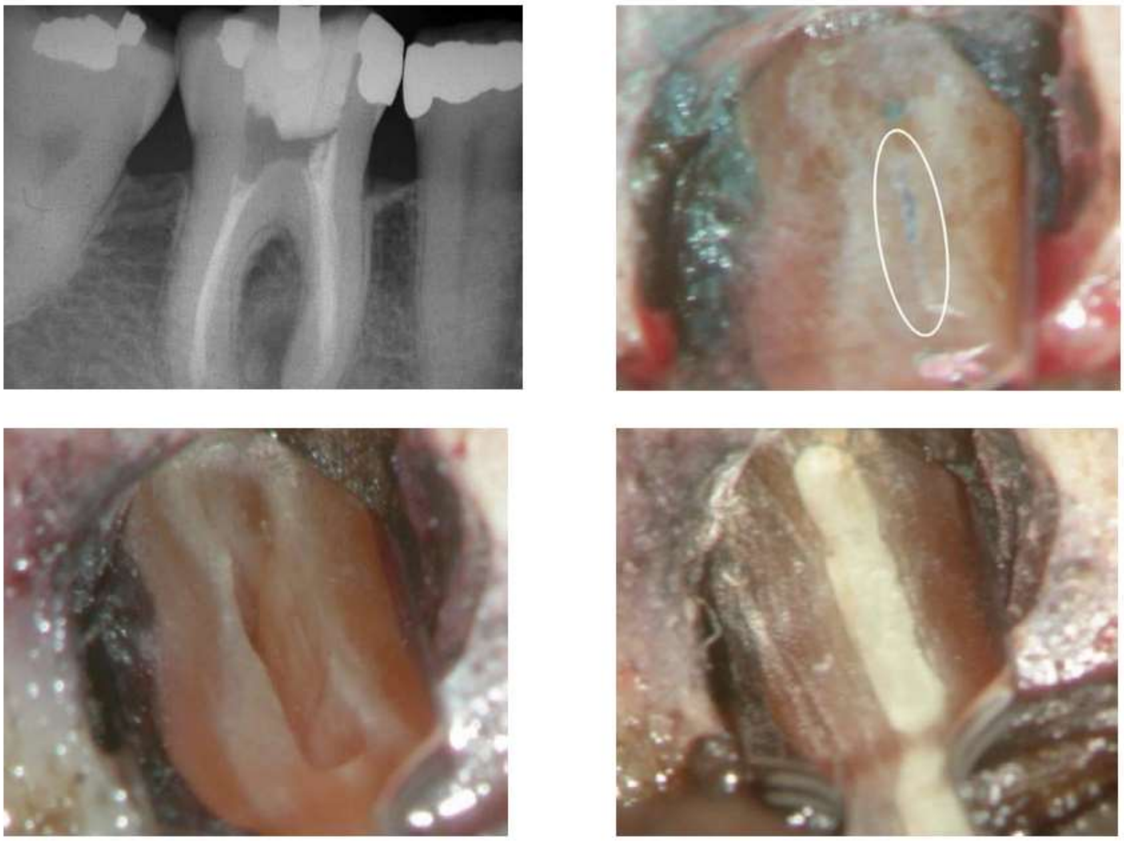

Fig. 52- Surgical Re-treatment of a failed case of conventional root canal

Treatment with ledge formation

Indications for surgical endodontics

1. Periradicular disease associated with a tooth where iatrogenic or developmental anomalies prevent non-surgical root canal treatment being undertaken.
2. Periradicular disease in a root-filled tooth where non-surgical root canal retreatment cannot be undertaken or has failed, or when it may be detrimental to the retention of the tooth (eg obliterated root canals, teeth with full coverage.
restorations where conventional access may jeopardise the underlying core, the presence of a post whose removal may carry a high risk of root fracture).
3.Where a biopsy of periradicular tissue is required.

4. Where visualisation of the periradicular tissues and tooth root is required when perforation or root fracture is suspected.
5. Where it may not be expedient to undertake prolonged nonsurgical root canal retreatment because of patient considerations.

Contraindications to surgical endodontics

There are few absolute contraindications to endodontic surgery, however the following should be considered:

1. Patient factors, including the presence of severe systemic disease and psychological considerations.
2. Dental factors including:

• unusual bony or root configurations
• lack of surgical access
• possible involvement of neurovascular structures
• where the tooth is subsequently unrestorable
•where there is poor supporting tissue
• poor general oral status.

3. The skill, training, facilities available, and experience of the operator, should also be considered.

Radiological assessment

While a long cone parallel periapical view of the teeth and adjacent structures provides a good diagnostic yield, further information (eg root morphology in multi-rooted teeth, or when perforation by a post is suspected) may be gained by taking additional angled (horizontal/vertical) periapical radiographs. At least 3mm of the tissues beyond the apex of theroots should be radiographically assessed. If a large periradicular lesion is suspected further radiographs such as a dental pantomogram or occlusal views may be required. If a sinus tract is present then a radiograph should be taken with a gutta-percha cone in place to delineate the tract. Historical radiographs, if available, provide a longitudinal guide to changes in periradicular status. The high diagnostic yield of cone beam computed tomography has been described by Patel et al with particular reference to assessment of posterior teeth prior to periapical surgery.

Clinical Management

The use of chlorhexidine mouth rinses to reduce plaque formation may be beneficial. Systemic nonsteroidal anti-inflammatory drug therapy should be considered prior to surgery in order to reduce postoperative pain.

Anaesthesia

Where possible, local anaesthesia should be the method of choice. Haemostasis is of benefit at the surgical site, which is more easily achieved when a local anaesthetic containing a vasoconstrictor is used.

Magnification

The use and benefits of the dental operating microscope in terms of improved visualisation and control of the surgical site is well documented. The impact of magnification devices on the outcome of endodontic surgery had not been demonstrated until recently when Setzer et al reported a positive effect of magnification and a microsurgical technique on outcome.

Soft tissue management

Surgical flap design (Fig. 53) is variable and depends on a number of factors, including:
- Access to and size of the periradicular lesion
- Periodontal status (including biotype)
- State of coronal tooth structure
- The nature and extent of coronal restorations

• Aesthetics
• Adjacent anatomical structures.

Relieving incisions should be placed on sound bone. The lack of predictability in determining the size of the periapical lesion, combined with increased incidence of scarring associated with a semilunar flap, precludes its use in endodontic surgery, It is not desirable to remove bleeding tags of tissue from the exposed bone or periodontal ligament fibres that were severed during tissue reflection as they will facilitate healing. The raised flap must be protected from damage and desiccation during surgery and retractors should rest on sound bone.

Fig. 53- A surgical flap

Flap design

There are three principal flap designs for surgical endodontics:

• 'two-sided'
• 'three-sided' (trapezoidal)
• semilunar.

‘Two-sided’ flap

A relieving incision is made in the oral mucosa of the buccal sulcus, and the incision is extended around the gingival margin of the tooth to be treated . Preservation of the gingival attachment is preferred wherever possible. An advantage of this type of incision is the ease of repositioning of the flap after surgery. In most circumstances access to the apical tissues is satisfactory. If access is not sufficient, the gingival margin incision can be extended distally as far as is required, but failing that, a second relieving incision may be used; the flap is now a three-sided design.

‘Three-sided’ (trapezoidal) flap

The three-sided flap provides excellent access for most surgical endodontic procedures. There should be no undue tension on the flap while it is being retracted. A relieving incision should be avoided over thin oral mucosa where the surface of a root is prominent (such as the canine eminence), because the reduced blood supply may result in delayed healing or wound dehiscence. A disadvantage of a three-sided flap is the risk of postoperative recession at the gingival margin. This is distressing for some patients, and may require a new crown or veneer to improve aesthetics. The flap can be more difficult than the two-sided design to reposition accurately. A modification of the three-sided fl ap leaves a 3- to 4-mm rim of gingival tissue in situ. This design (the so-called Luebke-Ochsenbein flap design) usually provides satisfactory access to the apical tissues. Although this flap is prone to wound dehiscence, it usually gives a good aesthetic result.

Semilunar flap

The semilunar design avoids the gingival margin, and there is less risk of recession of the gingival tissues after surgery. However, there are three main disadvantages of the semilunar flap design:

• Surgical access to the apical tissues may be restricted
• It is often difficult to ensure the incision line ends up resting on bone
• The flap sometimes results in wound dehiscence 56.

Flap reflection

The periosteum should be raised with care because tears can result in more postoperative pain and swelling. Flap reflection may be difficult if a sinus is present, or if fibrous scar tissue is present after previous surgery. The sinus or scar tissue is dissected from the flap with a scalpel or blunt-tipped dissecting scissors, and the resultant defect is sutured at the end of the procedure. A conventional flap retractor (e.g. the Bowdler-Henry rake retractor) is satisfactory, but specific apicectomy retractors exist.

Hard tissue management

Osteotomy

An assessment of the length of the root and its axis should be made to ensure that bone is removed accurately from the desired site. If the cortical bone plate is thin or absent, curettes may be used to expose the apex of the root. Further bone removal should be carried out with a bur in a reverse-air handpiece, cooled by copious sterile saline or sterile water. Steel or tungsten carbide burs produce less heat than diamond burs. The superficial osteotomy should be performed with a light shaving motion to reduce the heat generated and allow adequate visibility. Sufficient bone is removed to allow adequate access to the root end. A bony lid technique has been advocated for mandibular molar teeth. A microsurgical technique should be used where appropriate.

Periradicular curettage

The soft tissue in the periradicular region should be removed with curettes to allow adequate visualization of the root apex. In some cases it may not be possible to remove all the soft tissue around the root-end until the apex has been resected. The majority of the inflammatory soft tissue should be removed but the peripheral tissues may be reparative in nature and, if other anatomical structures are likely to be violated, then this tissue should be left. Pathological material should, if possible, be sent for histopathological examination.

Root-end resection

Fig. 54- Root-end resection

Resection of the root should be carried out as close to 90 degrees to the long axis of the tooth as possible to reduce the number of exposed dentinal tubules and to ensure access to all the apical anatomy. If possible, at least 3mm of root end should be resected with a rotating bur (using saline or water coolant) thus eliminating the majority of anatomical and/or iatrogenic anomalies in the apical third. The resected root surface should be examined, preferably under magnification (Fig. 54) with a micro-mirror, to en-sure that the resection is complete, that the surface is smooth and that there are no cracks in the root, and to check for canal irregularities. The application of a neutral, buffered, sterile dye to the root face may help visualisation of cracks as well as the outline of the root.

Root-end preparation

The preparation should be 3mm deep, in the long axis of the tooth and incorporate the whole pulp space morphology. To achieve these objectives root-end preparation is best carried out with an ultrasonically powered tip. In comparison with a bur in a micro-handpiece, the use of ultrasonic tips minimises the amount of bone removed to gain access for root-end preparation, allows a preparation that more readily follows the long axis of the canal, and facilitates debridement of isthmuses. The tips should be used at low power and with a light touch to reduce the risk of root cracking. Root end preparation should be carried out with sterile saline or water as a coolant. Consideration should be given to removing the smear layer with EDTA or citric acid, especially if a bur has been used. The root-end cavity should be examined to ensure that the walls are free of debris, including previous root filling materials.

Root-end filling

Fig. 55- Root end filling

The root-end preparation should be isolated from fluids, including blood. A suitable haemostatic agent should be placed in the bony crypt and the root end cavity dried. The root-end filling material should be compacted into the cavity with a small plugger to ensure a dense fill (Fig. 55). There should be no excess material on the resected root face. A biologically compatible material should be used where possible. Mineral trioxide aggregate is an osteo and cement-inductive material and is associated with a high clinical success rate. Of the other materials that have been investigated super EBA, glass ionomer, composite resin (with a dentine bonding agent) and reinforced zinc oxide-eugenol are also considered suitable. Amalgam is not recommended. There should be careful debridement of the bony crypt to ensure that haemostatic agents, root-end filling material and debris are removed. Radiographic verification of the quality of the root end filling is appropriate before wound closure.

Closure of the surgical site

The soft tissue flap is re-apposed with sutures, optimum healing being achieved with primary closure. After suturing, the tissues should be compressed with damp gauze for 3–5 minutes. Sutures are removed hours post-operatively (providing the wound is stable), when reattachment of the periodontal fibres at the gingival margin has taken place. Sutures left longer than this may become infected by „wicking", particularly if they are of the multi-filament type. Synthetic monofilament sutures are therefore the preferred choice in order to minimize microbial colonisation.

Post-surgical considerations

Post-operative complications should be uncommon. Post-operative pain may be controlled with non-narcotic analgesics. A long-acting local anaesthetic given at the end of the procedure may also be beneficial. Long-term pain as a result of surgical damage to the peripheral nerves occurs rarely.

Haemorrhage

Must be controlled intra-operatively. Soft tissue bleeding is controlled by haemostatic agents delivered via local anaesthetic, epinephrine pellets, ferric sulphate, electrosurgery and/or with sutures. Bleeding in the bony crypt is also affected by the vasoconstrictor in the local anaesthetic agent and topically applied agents. The latter should be removed from the crypt prior to closure of the surgical site.

Post-operative swelling

Minimised by applying cold compresses with an ice pack for the first 4–6 hours after surgery. Chlorhexi-dine mouthwashes help to prevent plaque accumulation for the period when tooth brushing is less than optimal.

Ecchymosis

Patients should be informed that bruising may occur, that it is self-limiting and will usually resolve within two weeks of surgery.

Infection

Infection of the soft tissues may result in secondary haemorrhage, cellulitis or local abscess formation. It is best prevented by maintenance of good oral hygiene measures and the use of chlorhexidine mouthwashes immediately pre-operatively and post-operatively. Antimicrobials should be prescribed where signs of systemic involvement are present with pyrexia and regional lymphadenopathy, in combination with surgical drainage if appropriate. Clear, written post-operative instructions given to the patient, together with telephone communication within 24 hours avoids misunderstandings and allows further supportive care and advice.

Outcomes of surgical endodontic intervention

An initial review appointment is required to remove sutures and assess early healing. Thereafter, regular review appointments should be made to assess healing using criteria based upon clinical and radiological examination. Radiological examination should be conducted at annual intervals until healing is observed. Periapical radiographs should be taken, endeavouring to achieve the same angulation as the pre-operative view to allow accurate comparison. Outcomes may be classed as successful, incomplete, uncertain and unsuccessful. Outcomes must be defined and quantified to enable audit to establish best practice, as there is a shortage of reliable clinical data. A range of 37–91% has been reported for healing following surgical endodontics.

Successful outcome

Clinical

This is achieved when the presenting symptoms and signs of the disease associated with the tooth have been eliminated.

Radiological

The treated tooth should show a normal periodontal ligament width or a slight increase, not wider than twice the normal periodontal ligament space. The periradicular rarefaction should be eliminated and the lamina dura and osseous pattern should be normal. There should be no root resorption evident. Clinical criteria cannot be used to determine the amount and type of repair histologically. The aim should be to provide an environment that allows regeneration of the cementum and periodontal ligament over the resected root apex. However, in many cases repair of the tissue takes place with the formation of a fibrous tissue scar.

Incomplete outcome

Clinical

There are no signs and symptoms.

Radiological

There is partial regeneration of the periapical bone. This may be due to the formation of fibrous scar tissue and is often associated with a through and through lesion where both buccal and lingual cortical plates have been perforated by infection or during the surgical procedure.

Uncertain outcome

Clinical

There may be vague symptoms, which may include mild discomfort or a feeling of pressure and fullness around the treated tooth.

Radiological

There is partial regeneration of periapical bone

Unsuccessful outcome

Clinical

The presence of signs and/or symptoms of periradicular disease, including root fracture.

Radiological

There is no regeneration of periapical bone

Should failure occur after surgery then the cause needs to be established prior to a plan of treatment. Further surgical intervention has been associated with a lower success rate 56 (35.7%).

GENTLE WAVE PROCEDURE

It is a multi-ultrasonic cleaning procedure that is a minimally invasive alternative to standard root canal treatment. This enables procedure fluids to reach through the entire root canal system providing efficient cleaning of the complex canal anatomies. Multi ultrasonic cleaning means multiple frequencies are generated at the same time when this technology is paired with optimized procedure.

Uses:-

1. Efficacy in tissue dissolution

2. Efficiency in Removing Inter-appointment Intra-canal Medicament The performance of the GentleWave™ System to remove intra-canal medicament, even in the apical third regions of the root canal system was demonstrated.58 Using a complete treatment cycle of seven minutes and 45 seconds, the GentleWave™ System.

completely removed calcium hydroxide ($Ca(OH)_2$) from the entire root canal system including the apical third regions.

3. Effectiveness of the GentleWave System in Removing Separated Instruments.59

Advantages:-

1. The GentleWave System provides tissue dissolution of eight and ten times faster than ultrasonic devices and needle irrigation, respectively.60
2. The GentleWave System results in negative pressure and zero extrusion at the apex.61,62
3. To use the GentleWave System, the teeth have to be only minimally instrumented e.g.: size 15/04. The resulting fluid dynamics, multisonic sound waves, and sono-chemistry, enable the treatment fluids to penetrate and reach complex areas such as apical-thirds, isthmi, lateral fins, dentinal tubules, and other anastomoses.63, 64, 6this cleaning system composes of a portable treatment unit with a single-use sterile handpiece. Irrigant solutions of NaOCl, distilled water and EDTA are included in this cleaning system.
4. Recent clinical study shows that only 3% of the patients experience moderate post-treatment pain, and 97% of successful healing in the teeth treated with the GentleWave System at 12 months.66

According to Asgeir Sigurdsson et al Histological analyses showed 97.2% of tissue debris in apical and middle region of mesial roots of mandibular molars, including isthmus, was removed after treatment with the GentleWave System57.

CONCLUSION

With a continuing improvement in oral health and a change in patient attitude, it is no longer acceptable to extract teeth simply because of periapical disease and endodontic failure. Advances in scientific knowledge and technical skills have helped improve the prognosis of treatment, but it may not always lead to the desired healing response in clinical practice.

If initial treatment is unsuccessful, practitioners are increasingly expected to possess the necessary knowledge and skills to perform ever more technically demanding procedures to save teeth. The focus on evidence-based treatment has resulted in secondary care providers, such as local oral surgery units, no longer being willing unquestioningly to accept failing endodontic cases for surgery, prior to an attempt having been made to retreat by non-surgical means.

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