Journal of Advanced Medical and Dental Sciences Research
@Society of Scientific Research and Studies
Journal home page: www.jamdsr.com doi: 10.21276/jamdsr UGC approved journal no. 63854
(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805 SJIF (Impact factor) 2017= 6.261; Index Copernicus value 2016 = 76.77

Original Article

Prognostic Evaluation of Subjects Undergoing Root-end Surgeries for Persisting Peri-Radicular Pathologies Following Ineffective Endodontic Retreatment: A Comparative Clinical Study

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ABSTRACT
Introduction: Surgical endodontics is concerned with the diagnosis and treatment of periapical lesions of endodontic origin that cannot be treated or do not respond to conventional endodontic therapy. The objective of periapical surgery is to seal the root canal system, enabling healing by forming a barrier between the irritants within the confines of affected root and periapical tissue thus by surgical intervention maintain a tooth in oral cavity that primarily has an endodontic lesion that cannot be resolved by conventional endodontic re-treatment. So for the success, it becomes of clinical relevance to perform a thorough clinical and radiographic examination of the tooth before endodontic surgery. **Materials and Method:** An elaborated clinical study was conducted at our Dental College & Hospital, Lucknow. A total of 34 patients with chronic periapical lesions were treated by periapical surgeries using rotary burs and ultrasonics under 3.5x magnifying loupes to prepare root-end cavities, and retrograde filling with MTA. The study was pre-approved by the ethics committee, and an informed consent was obtained from each patient. The study was conducted by the Department of Endodontics in collaboration with the Department of Oral & Maxillofacial Surgery. The patients were analysed (follow-up) for the period of atleast 12 months after treatment. The patients so analysed were from an age group of 18 years to 50 years of age. Patients so selected for the analysis and treatment had buccal bone defect (minimal bone overlying the root structure), which had occurred due to the failure of the root canal treatment or re-root canal treatment. The data were collected using a set protocol for each patient and later statistically analysed. **Results:** A total of 34 patients were analysed, out of which 12 patients underwent root canal treatment for first time and remaining 22 patients were re-root canal treatment cases. Out of 22 patients of re-root canal cases, 11 patients showed positive clinical and radiographic parameters with bony defect correction visible within 12months of the periapical surgery as per von Arx and Kurt B *et al*.(1998), Mikkonen *et al*.(1983)and Rud *et al*.(1972) criteria. In this same group 2 patients showed minimal visible changes even after 12 months of the surgery. **Conclusion:** Root-end endodontic surgery is considered as a predictable treatment option to save a tooth with apical pathology that might not be managed by conventional, non-surgical endodontics.
Key words: Apicoectomy, Clinical study, Retrograde filling, Root-end surgery, Surgical endodontics

Received: 27 September 2018 Revised: 24 November 2018 Accepted: 28 December 2018

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This article may be cited as: Jain G, Bedi RS, Rajkumar B, Boruah LC. Prognostic Evaluation Of Subjects Undergoing Root-end Surgeries For Persisting Peri-Radicular Pathologies Following Ineffective Endodontic Retreatment: A Comparative Clinical Study. J Adv Med Dent Scie Res 2019;7(1):50-57.

INTRODUCTION

Endodontic treatment is usually performed in teeth with periapical lesions. However, in some cases this periapical periodontitis/pathology persists and for the treatment of this non healing periapical lesion after nonsurgical retreatment or in some situations even in primary edodontic treatment, endodontic root-end surgery is indicated.[(1,2)] This procedure can address both intracanal and extra-radicular infections that may have contributed to the negative outcome of the primary treatment done.[(1)] A typical peri-radicular surgery is an approach to treat non-healing periapical lesions and it is an extension of an endodontic treatment, which includes making a periosteal incision for removal of tissues other than the contents of root canal, closure of external root perforations, in order to retain a tooth with pulp or periapical involvement and regain its functional utility in oral cavity. Thus it is considered last treatment option to retain the tooth in

function inside oral cavity before its extraction. Endodontic surgery was originally started with an incision made by Greek physician Aetius to drain an acute abscess more than 1500 years ago.[3] Later, as the need for endodontic surgery was emphasized with importance to focal infection in dentistry, surgical endodontic intervention emerged as a significant treatment modality to retain sound teeth and a basis for its application techniques and concepts was established by the foundation of American Association of Endodontics.[4]

Although endodontic therapy produces a successful result but failures are observed in 10-15% of cases.[5] These failures can be due to persistent infection in periapical tissue or because of certain procedural errors such as instrument separation in canal or beyond root apex periapically, apex transportation, perforation and short or overflow of root canal filling. But these procedural errors constitute only 3% of cases that require surgical intervention.[6] Nair *et al.*[7] observed that periapical healing could be achieved specially in cases of Radicular cyst with traditional root canal treatment since some of these cyst do not open into the canal apex.

However, the endodontic retreatment of teeth seems to be a more conservative approach, the tooth fracture rate increases because of re-instrumentation of tooth. So, when root canal retreatment and endodontic surgery are evaluated, there seems no significant difference between their success rates although the prognosis differed between the observed cases.[8]Though endodontic literature lacks litancy of predictability for surgical endodontics, but when it is coupled with use of magnifications (surgical operating microscope or magnifying loupes), refined principles of soft and hard tissue management, use of tissue regenerative biocompatible root-end filling materials, and enhanced principles of wound closure and post operative management, it emerged as a highly predictable and relatively painless procedure.[9]

The objective of periapical surgery is to surgically maintain a tooth that primarily has an endodontic lesion that cannot be resolved by conventional endodontic re-treatment. So, it becomes of clinical relevance to perform a thorough clinical and radiographic examination of the tooth before apical surgery. Apicoectomy was the classic term applied to surgical endodontic procedure, which may or may not include the preparation and filling of the root-end cavity. Root-end surgery is the terminology used in the American Association of Endodontics Glossary of Endodontic Terms that addresses endodontic surgery involving contemporary techniques for root-end preparation and root-end filling or other methods for retrograde sealing of the apically resected root surface.[1]

According to the updated guidelines by the European Society of Endodontology, the indications for root-end surgery include[10] radiological findings of apical periodontitis and symptoms associated with an obstructed canal, where the obstruction proved not to be negotiable, and the displacement did not seem feasible or the risk of damage is considered too much,[11] extruded endodontic material with clinical or radiological findings of apical periodontitis and symptoms continuing over a prolonged period of time, [12] long standing or emerging disease following root-canal treatment when root canal re-treatment is not correct, and perforation of the root or the floor of the pulp chamber and where it is not feasible to treat from within the pulp through access cavity, as conventional root canal treatment.[13] The use of a surgical microscope is advised in apical surgery since it allows clear focus of the surgical field at high magnification with excellent and focused illumination of microstructures (additional canals, isthmus) and root integrity including cracks, fractures, perforations, demarcation between bone and root, and identification of adjacent important anatomical structures. The incision and flap design should be predefined according to clinical and radiographic examination, including condition, biotype and width of gingival tissues, presence of a restoration margin, location and extent of the peri-apical lesion, and patient's aesthetical requirements.

The aim of present study was to determine the prognosis and success rate of root-end surgeries carried following endodontic treatment failure in the studied patients by assessing post operative peri-radicular healing on basis of clinical and radiographic parameters.

MATERIAL AND METHODS

An elaborated clinical study was conducted at our Dental College & Hospital, Lucknow. A total of 34 patients with chronic periapical lesions treated with periapical surgeries were included in the present in-vivo study which was pre-approved by the ethics committee, and an informed consent was obtained from each patient. The study was conducted by the Department of Endodontics in collaboration with the Department of Oral & Maxillofacial Surgery. In order to control the methodological quality and study outcome with results, teeth that have undergone a root-end surgery and root-end filling procedure were only included in the study.

Pre-Treatment Evaluation:

Similar to other dental procedures, blood investigations were done for systemic diseases identification specially for bleeding disorders. Patients with normal complete blood picture and coagulation study report were included in the study. Necessary radiographic and clinical investigations were done for evaluation of:-

- Tooth root restorability for prognosis.
- Root canal filling for patency of obturation in cases of root canal treated teeth and if and where required re-root canal treatment was performed.
- Relationship between root apex and major anatomical structures like mental foramen, mandibular canal and its neurovascular bundle, maxillary sinus, nasal floor and anatomic limitations to adequate visual and mechanical access to surgical site.

Patient Selection:
The patients so analysed were from an age group of 18 years to 50 years of age.(Table1) Patients selected for the analysis and treatment included those which had non-healing periapical lesions in relation to maxillary and mandibular anterior teeth only and had solely buccal bone defect, which had occurred due to the long standing untreated diseased tooth or failure of the root canal treatment or failure of re-root canal treatment.

Inclusion Criteria:
- Clinical procedure requiring root-end surgery.
- A minimum follow-up period of 1year after treatment.
- Root-end surgery performed with a technique or a combination of technique that fit the specified criteria for all the patients included in the study.
- Use of ultrasonic for root-end cavity preparation and root-end filling with MTA only.
- Patient undergoing treatment for maxillary and mandibular anterior teeth only.

Exclusion Criteria:
- Periapical lesions more than 10mm in diameter.
- Teeth presenting mobility.
- Use of guided tissue regeneration.
- Surgery after previous endodontic surgery (re-surgery cases), root resections, amputations and cases presenting with root fractures or perforations.
- Follow-up of less than 1yr after surgery.
- Patients where the outcome was not evaluated according to the success and failure criteria defined for the present study.

Informed consent was taken from all the patients included in the study. Data were collected using a pre set protocol for each patient which included clinical and radiographic assessment for root-end surgery in terms of success or failure, determined as per von Arx and Kurt B *et al*.[14], Mikkonen *et al.*[15]and Rud *et al.*[16] criteria.

Treatment Plan:
- Oral Prophylaxis
- Prophylactic antibiotic (Amoxicillin 500mg + Potassium Clavulanate 125mg) coverage
- Root canal treatment or Re-root canal treatment as per requirement
- Surgical Management of periapical lesion, root end resection, root-end cavity preparation followed by filling with MTA
- Recall and follow-up after surgery

Root canal treatment / Re-root canal treatment:
Local anaesthesia was administered, under rubber dam (Dentsply Maillefer, Switzerland) isolation, access cavity was done with Endo-access Bur and Endo-Z Bur (Dentsply Maillefer, Switzerland) using high speed airotor hand piece (air turbine) (NSK, Japan) at 3,00,000 rpm under water coolant spray and a straight-line access was prepared to facilitate instrumentation and obturation. Canal patency was established with DG-16 (GDC, India) explorer and ISO size 10 K-Flex file (Dentsply Maillefer, Switzerland). Working length was determined by apex locator and verified radiographically and canal patency was maintained by inserting an ISO size 15 K-Flex file till the apical foramen. In re-root canal cases, Endosolv (Septodont, India), hand H-file and R-Endo rotary files (Micro Mega, France) were used for root canal GP removal prior to working length determination. Cleaning and Shaping of the root canals were performed using Heroshaper (Micro Mega, France) rotary files 30/0.04 taper for mandibular anterior teeth and 30/0.06 taper for maxillary anterior teeth till working length using crown-down technique with alternate irrigation of 3% sodium hypochlorite (NaOCl) (Vishal Dentocare Ltd., India) solution and saline (Nirlife, Nirma Ltd.(Healthcare Division), India). Glyde™ (10% carbamide peroxide and 15% EDTA gel) (Dentsply, USA) was used during instrumentation with each file size in all the teeth. Two percent chlorhexidine (CHX) was used as final irrigating solution. Root canals in all the teeth were dried with absorbent paper points and later obturated using gutta-percha cones of respective sizes followed by multiple cone technique using lateral compaction method with AH-Plus sealer (Dentsply, USA). The gutta-percha cones were cut at the orifice level and access cavity was later filled with permanent restoration using Type IX glass-ionomer cement (GIC) (GC Fuji, America) restoration.

Surgical Technique:
Under local anesthesia, a full thickness mucoperiosteal flap was elevated at the buccal aspect, following intracrevicular incisions and vertical releasing incision. After reflection of periosteal flap, thorough degranulation and debridement was done at the defect area using Gracey and Lucas curettes (Hu-Friedy, Brazil). For the histopathological examination, the granulation tissue was fixed in 10% buffered formalin. The surgical site was washed with sterile saline solution after complete removal of the lesion to remove any remaining detached fragments from the defect and surgical field. Apical 3mm of the root was resected using round bur and a root-end cavity was prepared using ultrasonics (Biosonic, ColteneWhaledent, USA). This was done in accordance to previous study by von Arx T *et al*.[17] HEINE® Magnifying Loupes (HEINE®, USA) of 3.5x magnification were used to facilitate the procedure. After root conditioning with tetracycline hydrochloride solution, adequate isolation of area was done with proper bleeding control, followed by retrograde filling with Mineral trioxide aggregate (MTA) (Angelus®, Brazil). A periapical radiograph was taken for confirmation of accuracy of retrograde filling. Bone graft material (sterile hydroxyapatite and β tricalcium phosphate granules) (BioGraft-HA® NANO, India) was carried to the area with bone graft carrier and placed in increments with proper condensation. After placement of resorbable membrane over the bone graft, the flap was then secured with non-resorbable silk suture (Ethicon, NJ) using

interrupted suturing technique.(Figure 1(a) to 1(j)) The patient was advised proper plaque control and prescribed 0.2% chlorhexidine mouthwash for rinsing twice daily for 2 weeks. The sutures were removed 10days after surgery. Patient was recalled for every 2 months follow-up. Radiographs were obtained for future comparison.

Prognostic assessment of healing:

The following criteria were used to evaluate the success of root-end surgery:-

- The clinical and radiographic criteria of von Arx and Kurt*et al.*[14] to determine overall evolution:
  1) Success: when boneregeneration was ≥90% and the pain and clinical scales were 0 (on a scale of 0 to 3);
  2) Improvement: when bone regeneration was between 50% and 90% and the pain and clinical scales were 0;
  3) Failure: when bone regeneration was less than 50% or there were clinical symptoms.
- The clinical criteria of Mikkonen *et al.*[15], considering:
  1) Success: when there is no pain, swelling or fistula;
  2)Uncertain healing: radiographic evidence of bone destruction and presence or not of symptomatology;
  3)Failure: when there is bone destruction, root resorption and symptomatology.
- The radiographic criteria of *Rud et al.*[16]:
  1) complete healing: complete bone regeneration, normal or slight increase in width of periodontal periapical space, but less than double the width of the unaffected radicular areas;
  2) Incomplete healing: reduced radiolucency, characterized by signs of bone healing around the periphery of the rarefaction;
  3) Doubtful healing: reduced radiolucency with one or more of the following characteristics: the radiolucency was greater than twice the width of the periodontal space, it was bordered by a structure such as hard lamina, it had a circular or semi-circular periphery, or was located symmetrically 'cone-like' around the apex as an extension of the periodontal space;
  4) Radiographic failure: there were no changes, or there was an increase in radiolucency.
- Finally, it was evaluated if the tooth was functional (remained in place) or not.

Analysis was done using SPSS 19 software for data obtained.

RESULTS

A total of 34 patients were analysed, out of which 12 patients were first time root canal cases and 22 were re-root canal cases.(Graph1) (Table1) Out of 22 patients of re-root canal cases, 19 patients showed positive results with bony defect correction of more than 50% visible within 12 months of the surgery. In this same group 2 patients showed very minimal changes of bone regeneration, less than 50% even after 12 months of the surgery so the prognosis was considered as poor. (According to von Arx and Kurt *et al.*[14], Mikkonen *et al.*[15] and Rud *et al.*[16] criteria) In group of first time root canal cases, all 12 patients showed positive results with bony defect correction of more than 50% visible within 12months of the surgery. (According to von Arx and Kurt *et al.*[14], Mikkonen *et al.*[15] and Rud *et al.*[16] criteria) (Table 2) (Figure 1) All the patients were categorised according to the age, treatment offered and the results obtained manually and later on interpreted electronically. (Table1)

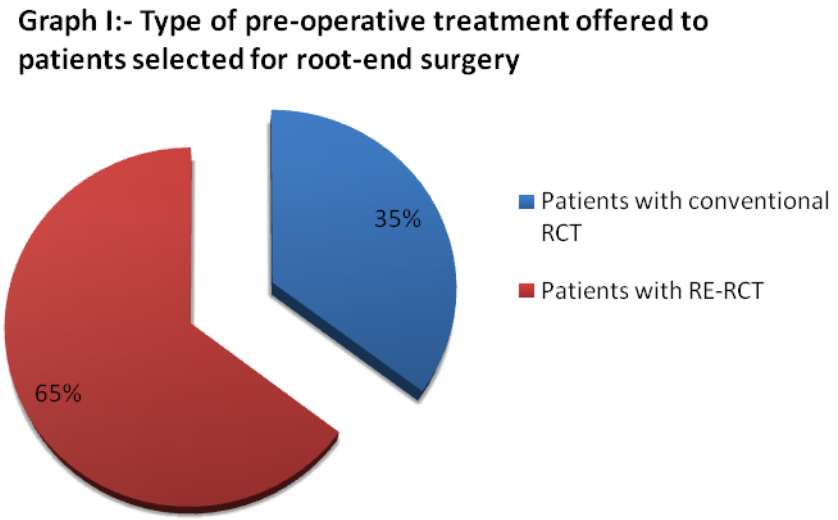

TABLE 1: Distribution of patients according to age and pre-operative treatment offered

AGE	RCT	RE-RCT
18-29	4	9
30-39	4	9
40-50	4	4
TOTAL	12	22

Table 2: Success rate of periapical surgery in terms of Healing percentage recorded according to three different criteria

		12 Months Follow-up post surgery	
		1st time Root canal treatment cases	Re-root canal treatment cases
Clinical Scale (von Arx and Kurt *et al.*)	No Clinical Sign	75%	54.54%
	Pain on Palpation in Apical area	25%	22.72%
	Pain on Percussion and apical inflammation	0	18.18%
	Sinus or Fistula (Abscess present)	0	4.54%
Radiographic Scale (vonArx and Kurt *et al.*)	More than 90%	83.33%	59.09%
	Between 50% - 90%	16.66%	27.27%
	Less than 50%	0	13.63%
Clinical Scale (Mikkonen *et al.*)	Success	91.66%	81.81%
	Improvement	8.33%	9.09%
	Failure	0	9.09%
Radiographic Scale (Rud *et al.*)	Complete Healing	66.66%	50%
	Incomplete Healing	33.33%	31.81%
	Doubtful	0	13.63%
	Failure	0	4.54%

Figure 1: Root-end surgery case for 1st time root canal treatment patient.

Fig. 1(a)

Fig. 1(b)

Fig. 1(c)

Fig. 1(d)

Fig. 1(e)

Fig. 1(f)

Fig. 1(g)

Fig. 1(h)

Fig. 1(i)

Fig. 1(j)

Fig. 1(a): Pre- operative Radiograph. **Fig. 1(b):** Pre- operative photograph of the patient. **Fig. 1(c):** Post-obturation Radiograph. **Fig. 1(d):** Post-obturation post placement in tooth #11, #21 and core build-up in tooth #11,#12, #21. **Fig. 1(e):** Full thickness mucoperiosteal flap raised and granulation tissue removed. **Fig. 1(f):** Root resection done and later root-end cavity prepared using ultrasonicsfollowed by retrograde filling with Mineral trioxide aggregate (MTA) in tooth #11, #12. **Fig. 1(g):** Bone graft material placed. **Fig. 1(h):** Flap secured after placement of resorbable membrane over the bone graft with non-resorbable silk suture using interrupted suturing technique. **Fig. 1(i):** Immediate post-operative radiograph. **Fig. 1(j):** 12 month follow-up radiograph.

DISCUSSION

Traditional endodontic treatment aims to eliminate bacteria from root canal and establish an effective barrier against root contamination.[18] However, persistent chronic infection can lead to formation of a periapical lesion which cannot be eliminated alone with an effective endodontic treatment.[19] From the results of the present *in-vivo* study, we found that success rate in periapical surgery with root-end cavity preparation using ultrasonics and using MTA as root-end filling in first time root canal treated cases was about 75% at 12 months according to the von Arx and Kurt *et al.*[14]healing criteria.

Moreover, endodontic treatment can also fail for many reasons such as, diagnostic errors, persistence of infection in root canal because of improper treatment, instrument separation within and beyond the root apex or poor post obturation restorations having improper hermetic seal leading to periapical lesions requiring surgical intervention.The failure of nonsurgical root canal treatment is generally associated with the presence of residual bacteria or the reinfection of a previously disinfected root canal system or secondary infection.[20]Unsuccessful results can be related to persistent intraradicular infections found in previously non negotiated canals, dentinal tubules, or with the complex irregularities of the root canal system.[21,22]The extraradicular cause behind any endodontic failures includes periapical actinomycosis.[23] An immunological reaction caused by apically extruded endodontic materials, the collection of endogenous cholesterol crystals in the apical tissues, and a chronic unresolved cystic lesion.[24-26] Previously treated teeth with persistent peri-apical lesions might be corrected with nonsurgical retreatment, assuming the tooth is restorable and periodontally sound. Old chronic accidents have a negative effect on healing.[27]They might contribute to the establishment of infections at inaccessible apical areas which require a surgical intervention.[28]

Endodontic surgery is a standard procedure which enhances the retention survival rate of many teeth which cannot be treated by root canal treatment alone.Root-end surgery is required in cases of unsuccessful outcomes after primary root canal therapy followed by conventional nonsurgical retreatment. The aim of surgery is the removal of diseased peri-apical organic mass and the sealing of the apical root canal system to facilitate the regeneration of hard and soft tissues. It includes the formation of new attachment cells and connective tissue.[29]The implementation of microsurgical techniques in endodontics has improved the success rate of the treatment. In the present *in-vivo* study, the association of root canal treatment or re-root canal treatment and root-endsurgical procedure resulted in tooth survival in 12 months follow-up.

Conventional nonsurgical retreatment before or in conjunction with endodontic surgery has shown higher success rates than endodontic surgery without prior nonsurgical retreatment. During apical surgery, the lateral apical canals, exposed isthmuses, and accessory canals must be carefully located and treated.[2] Further, removal of 3-4mm of root apex is required to eliminate anatomic irregularities (apical ramifications and lateral canals) and contaminated (biofilms, bacteria and endotoxins) radicular hard tissues, with a high-speed rotating bur and coolant. The apical cut of root apex is done at right angle to the long axis of the root to minimize any leakage that may occur through cut dentinal tubules for good prognosis of periapical surgery.[9] In conjunction with this literature, in our study, apical 3mm of the roots was resected at right angle to the long axis of the root using round bur and a root-end cavity was prepared using ultrasonics and HEINE® magnifying loupes of 3.5x magnification to facilitate the procedure. The use of magnification during endodontic procedures enhances the vision of the operating field and provides a better control of instruments and placement of dental materials. This also allows an improved detection and management of anatomic variations and fractures. Literatures show, previous studies that used microscope have shown high rates of success for endodontic surgeries and non surgical retreatment.[30]

In the present *in-vivo* study, MTA was used as a root-end filling material. Literatures show, the long-term success of the case also depends on the superior sealing ability of a retrofilling material as well as its higher biocompatibility and stimulation effect in regeneration of periapical tissues.[31] MTA produces favourable prognosis as there is absence of inflammation, cementum and hard tissue formation. Parirokh and Torabinejad[32]also reported that MTA produced cementum formation in 23% of the subjects after 2-5 weeks of root-end surgery and more than 80% of the root-end cavities filled with MTA showed cementum deposition, 10-18 weeks post surgery.

Further, the bone graft used to fill the hard tissue (bone) defect in the present study was sterile hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$) and β-tricalcium phosphate ($Ca_3(PO_4)_2$) granules. These are osteoconductive biocompatible materials that offer a chemical environment that did not elicit an inflammatory response and provide a surface conducive to new bone formation.[33] These have the ability to dissolve, break down and allow new bone formation by acting as a scaffold on which osteoblasts act to form bone.

CONCLUSION

Endodontic surgery is a standard procedure which enhances the retention survival rate of teeth with chronic periapical lesion which cannot be managed by conventional, non-surgical endodontic treatment. During surgical endodontic treatment, necrotic tissue, debris and microorganism of the periapical lesions are completely removed. So, compared to nonsurgical endodontic treatment, healing in cases of chronic periapical lesion or periapical abscess is enhanced after root-end endodontic surgery. The use of magnification and illumination, preferably a surgical microscope or magnification loupes, radiographs for diagnosis and application of microsurgical principles are very important requirements for obtaining successful outcomes in root-end surgery. However, the root-end endodontic surgery is an invasive

procedure, so proper case selection and adequate surgical debridement of periapical lesion is of outmost importance in prognosis and favourable outcome of the surgical procedure.

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