Review

Microsurgical Repair of Root Defects – An Overview

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Abstract:

Root defects can be one of the many reasons for persistent periradicular infections in endodontically treated tooth. Endodontic microsurgical approach can be the treatment option for managing these defects with infections. This article summarizes about the diagnosis of various root defects and describes the general process of microsurgical approach for its repair. Further, it also explains how tooth with root defects can be conserved with endodontic microsurgery instead of extraction and tooth replacement.

Key words:

External root resorption, microsurgical repair, perforation, root defects, vertical root fracture.

Introduction:

Endodontic surgery is regarded as difficult process because of the difficulty in approximating the location of anatomical structures such as large blood vessels, mental foramen and maxillary sinus. Although the chances of damage to these structures are rare, traditional endodontic surgery is regarded as difficult due to its invasive nature and questionable outcome[1, 2.] Examination of failed clinical cases and extracted teeth reveal that, its difficult to locate, clean and fill all the complex apical ramifications with traditional surgical technique. These limitations can only be overcome by endodontic microsurgery technique with the use of, microscopes (with magnification and illumination) and microsurgical instruments[3].

The advantages of microsurgery include easier identification of root apices, smaller osteotomies, shallower resection angles that conserve cortical bone and root length, use of ultrasonics, use of MTA as root end filling material which is biocompatible and bio regenerative, use of monofilament sutures, and suture removal in [2-3] days, which makes healing faster. In addition, resected root surface under high magnification reveals anatomical details such as isthmuses, canal fins, microfractures, and lateral canals[1, 2, 4.]

Root defects in a tooth are not rare and can occur as external root resorption[5] root perforations[6] , vertical root fractures and cracks7, which if misdiagnosed and left untreated might lead to tooth extraction. With the advancements of endodontic microsurgery and development of microscopes, CBCT, microinstruments, ultrasonic tips, and biocompatible root end filling materials, more and more root root defects can be diagnosed and repaired successfully.

External root resorption is initiated in the periodontium and initially affects external root surfaces[8]. External root resorption is further classified based on the etiology as i) infective/ inflammatory conditions ii) traumatic injuries iii) pressure/mechanical stimulation iv) neoplastic

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conditions and cysts of the jaws v) systematic disorders and vi) idiopathic5,9. Root Perforation is the mechanical or pathologic communication between the root canal system and the external tooth surface[8]. As a result of perforation, there is destruction in the dentinal root canal wall along with the investing cementum which ultimately compromises the periodontal status and threatens the viability of the tooth[10-12]. Vertical root fractures are characterized by the cracks that begin in the root and extends towards the root surface, occurring most commonly in endodontically treated tooth[8].

Anatomical root defects such as dens in dente and dens evaginatus in immature teeth are also treated with endodontic microsurgery due to endodontic failure, anatomical problems and failure to gain access to all parts of the root canal system[13], [14]. Dens invaginatus is a developmental defect resulting from infolding of the crown before calcification has occurred. Dens evaginatus is an anomalous outgrowth of tooth structure resulting from the folding of the inner enamel epithelium into the stellete recticulum with the projection of structure exhibiting enamel, dentin and pulp tissue[8].

Clinical Symptoms, Investigation and Diagnosis:

Diagnosis of a tooth with root defect is much difficult due to the lack of direct access to the defect site and superimposition of tooth with other anatomical structures in radiographs [4]. However, with the knowledge of combination of multiple factors such as patients history, clinical examination, x-rays and recent advancements such as CBCT along with the exploratory microsurgery, might assist in the proper diagnosis of the existence and type of the root defect.

With the use of microscopes certain benefits can be obtained in microsurgery such as surgical field can be inspected at high magnification so that small but important anatomical details like lateral canals and isthmuses can be identified and managed. Removal of diseased tissue is precise and complete. Distinction between bone and teeth can be easily done at high magnification especially with methylene blue staining. At higher magnification, osteotomy can be made minimal resulting in faster healing and less postoperative discomfort. In addition, occupational and physical stress is reduced since using microscope requires erect position[3].

External root resorption: The investigation of external root resorption starts with the type of the etiologic factor it is associated with.

External inflammatory root resorption, on clinical examination tooth may exhibit pain on percussion, presence of draining fistula, and on electiric pulp tests, pulp will be unresponsive. Radiograph shows widening of the lamina dura, and apical surface shows ragged up appearance, causing shortening of the apical 1/3rd of the root surfaces as shown in fig 1(a).

(a)

(b)

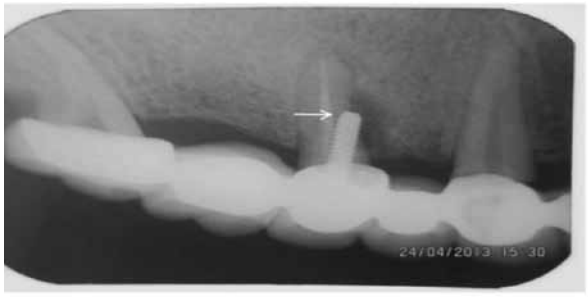
Fig 1(a) IOPA showing periapical radiolucency due to external root resorption; (b) CBCT section showing external root resorption

Cervical inflammatory resorption is present at the cervical region. A pink spot usually seen on the cervical region may be important in diagnosing the defect. Probing on the defect region may result in profuse bleeding[15]. In radiographs, the outline of the pulp canal will be intact indicating

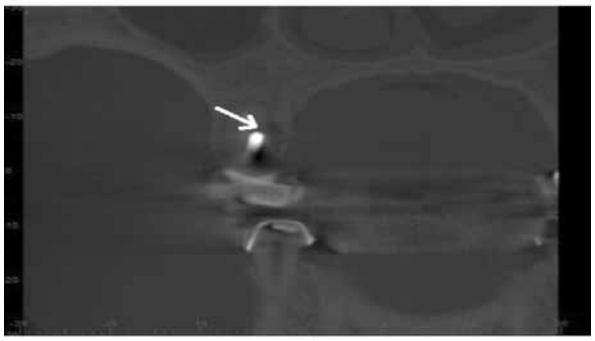
that the lesion lies on the outer surface. However, SLOB (Same Lingual Opposite Buccal) technique can be used to determine whether the defect is internal or external. CBCT can also be useful aid in diagnosing external or internal root resorption. It has been shown that conventional radiographic techniques revealed limited information on the true extent and nature of the resorptive lesion. But, using CBCT, the position, depth in relation to root canal, and finally the restorability can be assessed before any treatment is carried out[16, 17].

Other forms of external root resorption such as trauma induced, pressure induced or external root resorption as a result of neoplastic conditions and cysts of the jaws can also be diagnosed after detailed patient history and with the help of radiographs and CBCT.

Perforation: The etiology will play a major role in determining the diagnosis, whether it was already present or was created later. Radiographs from various anglulations will play a significant role. If radiographs are not convincing, then CBCT can be taken for specific diagnosis. especially when trying to locate the position of the defect, whether it is located buccally or lingually[18].



(a)



(b)

Fig2 (a) IOPA showing periapical radiolucency due to post perforation; (b) CBCT showing the same

Cracks and Vertical root fractures: The clinical symptoms of the vertical root fracture differs according to the location of the fracture, periodontal status of the tooth and the bone condition adjacent to the fracture[19]. Vertical root fracture can be suspected if a well filled tooth does not settle after root filling is completed. Other symptoms like pain on biting, deep narrow isolated pockets, bleeding during the condensation of the root filling materials, lack of resistance during obturation may be also seen[20]. Double or multiple sinus tracts may be present close to the attached gingiva rather than in the periapical region [7].

Radiographs may reveal separation of root fragments, fracture lines along the roots or root fillings, space besides a root filling, space beside a post, radiopaque signs due to extrusion of filling materials from the fracture lines, radiolucent halos in mesiodistal fractures can be seen[21]. V-shaped diffuse bone loss and dislodgement of the retrograde filling material can be also associated with vertical root fracture due to lack of retention[7, 22, 23].

Fig 3 : IOPA showing periapical radiolucency due to vertical root crack.

Surgical procedure:

After the diagnosis of the root defects as the cause for the existing periradicular infection has been established and the prognosis of the tooth determined, surgical procedure is initiated.

Access Preparation:

Access preparation has 2 parts: Soft tissue access and Hard tissue access.

Soft tissue access:

The basic soft tissue access window for all kinds of root defects is similar, with slight variations depending upon the anatomic structures (frenal

and muscle attachments, width of attached gingiva, bone eminence and papillary height and width), size and position of the defect itself, state of coronal tooth structure, nature and extent of coronal restoration and aesthetics[18, 24].

Various combinations of vertical and horizontal incisions are used to achieve various forms of full and limited mucoperiosteal flap. Microsurgical blade of #15C can be used for giving incisions.

Horizontal incisions:

i) Intrasulcular incision involving the dental papillae, if the defect is close to the marginal tissues, mostly indicated in lower anterior and posterior regions as shown in fig 4 (a and b).

ii) Submarginal flap (Oschsenbein Luebke Flap): Incision placed 2mm from the depth of gingival sulcus, and indicated in esthetically sensitive regions like upper anteriors as shown in fig 4(c and d).

The horizontal incison is normally extended to one sound tooth on both sides of the involved tooth.

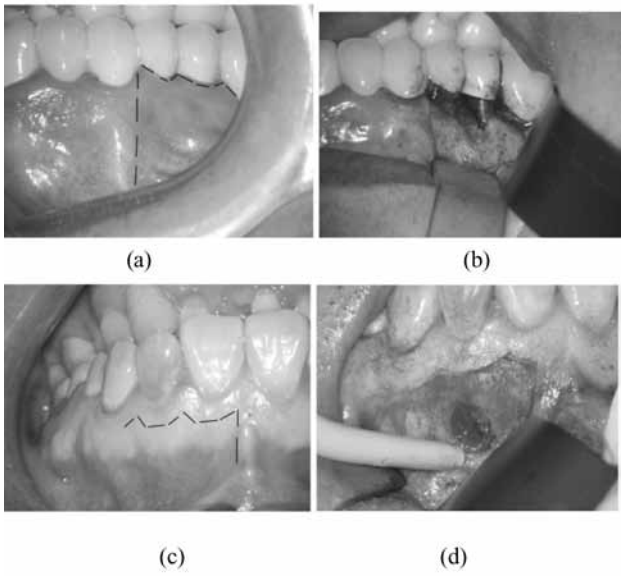


Fig 4 (a and b) Intrasulcular incisions: extensions and after flap reflection; (c and d) Submarginal flap: extensions and after flap reflection

Vertical Incisions:

2 full mucoperiosteal flaps can be designed depending upon the number of vertical releasing incisions. Triangular with one vertical releasing incision (as shown in fig 4), rectangular with 2 releasing incisions (especially when multiple teeth are involved or when the root length is long as in canine).

Currently, Vertical releasing incisions along the blood vessel alignment are indicated over the angled releasing incisions, as it severs less blood vessels, prevents ischemia, and provides adequate access to surgical site, and allows nearly scar free healing[3, 4].

Tissue Elevation and Reflection:

In both the intrasulcular incision and subgingival flap, whole of the mucoperiosteal complex should be elevated and reflected so as to minimize hemorrhage during the procedure[25]. The main objective of the tissue reflection and retraction is to provide adequate access for the management of damaged radicular defects, provide clear view of the bony surgical site (as shown in fig 5(b)) and prevent further soft tissue trauma[18].

If the defects are located on the cervical or mid root region as in the cases of external cervical root resorption, or perforations, then horizontal incision should be intrasulcular.

Hard tissue access and management:

During the hard tissue management, following things should be considered. Firstly, if the root defect is not directly accessible after soft tissue reflection, removal of the healthy bony tissue is required to gain access. It is then followed by periradicular curettage if granulation tissues are present. A proper cavity form is then prepared in the tooth to receive the restorative material. Then, a dry working field is created by using various hemostatic agents followed by placement of restorative material in the cavity[25]. A high speed surgical bur can be used to remove healthy bony tissue, while ultrasonics can be used to prepare the cavity in the tooth surface[18].

a. Hard tissue management in external root resorption:

Hard tissue management of external root resorption depends upon the type of the external root resorption. If it is external inflammatory root resorption occurring on the apical 1/3rd then conventional apical surgical method can be followed (as shown in fig 6). But, as the length of

the root is already reduced due to the resorption, resecting 3 mm is not required. Hence, resecting less than 3mm or sometimes only planing the root end surface is sufficient and then preparing a cavity, retro filling the prepared cavity and repositioning the flap is done[26].

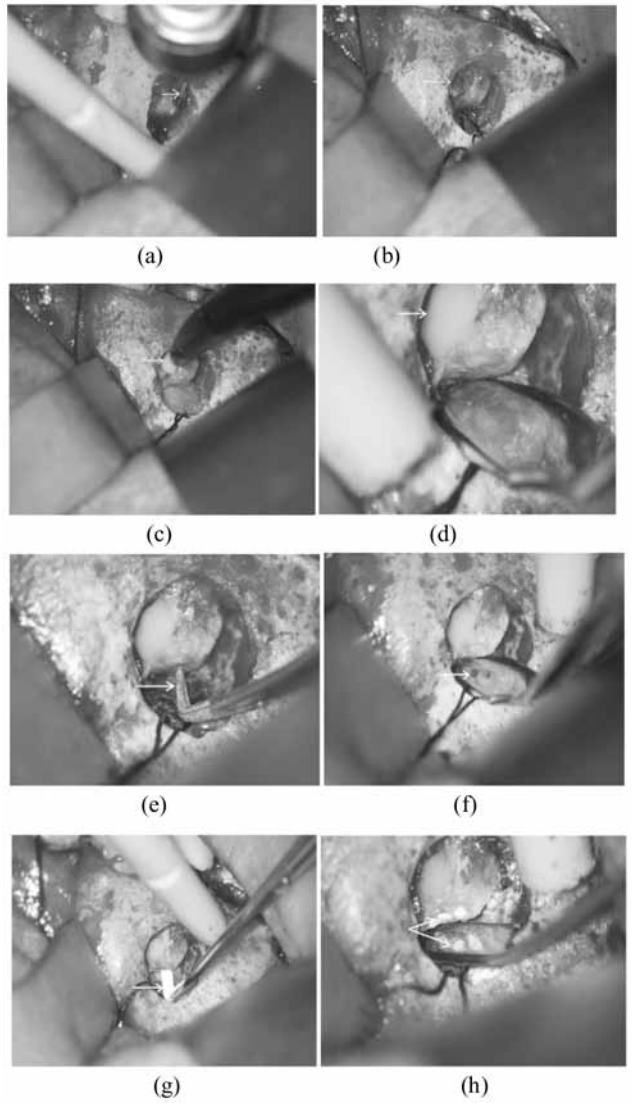


Fig6(a) Use of high speed hand piece with lindtmann bur to clean at external inflammatory root defect; (b) cavity after cleaning with high speed handpiece; (c) cavity restored with light cured GIC; (d)restored GIC; (e)Ultrasonics used to prepare root end cavity; (f) 2 cavities prepared with ultrasonics;(g) root end cavity restored with MTA; (h) after root end cavities restored with MTA.

In cases of cervical inflammatory resorption, surgical treatment varies with the depth of the lesion. If the defect are relatively smaller in size and does not involve the pulp, it can be treated by curetting the granulomatous tissue from the adjacent periodontium to sever the blood supply to the resorping cells[27, 28]. Several different types of burs can be used for removing the resorptive tissue, such as slow speed burs like muller bur, the LN bur, round #1 surgical length latch burs. High speed surgical length round #1 bur can be also used but with better control due to their superior cutting ability. Diamond coated ultrasonic instrument can also be used to remove affected dentin[29, 30]. The root defect can then be restored with flowable composite resins or glass ionomer cements.[27, 28]

But if the resorptive defect is in close proximity to the pulp or already exposed but were only diagnosed after the flap reflection, then endodontic treatment should be carried out before external repair of the external cervical resorption[28]. Performing the root canal treatment through the existing defect if possible can be attempted to prevent further destruction of the tooth structure. If it is difficult to attempt the endodontic treatment from the defect region, then the tooth can be first restored at the defect and endodontic treatment can be completed subsequently through conventional access cavity preparation. The patency of the root canal can be obtained by placing a finger spreader or gutta percha in the canal and prevent occluding the canal system. Then, the endodontic treatment can be completed later on[6].

The other forms of external root resorption can also be treated accordingly after the primary etiologic factor has been removed.

b. Hard tissue management of root perforations: Management of root perforation are similar with root end surgery. If there is the region of persistent periradicular lesion due to iatrogenic cause or due to the extension of internal root resorption and the cortical bone is already resorbed, then the granulation tissue is removed by using regular curettes with concave surfaces in a scraping manner as in root-end surgery[4, 18, 31, 32]. If the cortical bone is intact then the hard tissue access window is created by using high speed handpieces with multi-fluted burs such as Lindeman burs with continuous water coolant to prevent the heat generation in the bony crypt[33, 34]. Then, the soft tissue lesion is removed as described earlier and the site of perforation on the root surface is located. Then the ultrasonic root end preparation tips can be used to clean

and prepare the cavity form. This process can further be facilitated by the use of dental operating microscopes in conjunction with microsurgical instruments to enhance adequate vision and convenience35, 36. If the cavity form is proper box cavity and encased in bone then MTA can be the material of choice for restoring the cavity, otherwise flowable composite resins or glass ionomer cements can be used6.

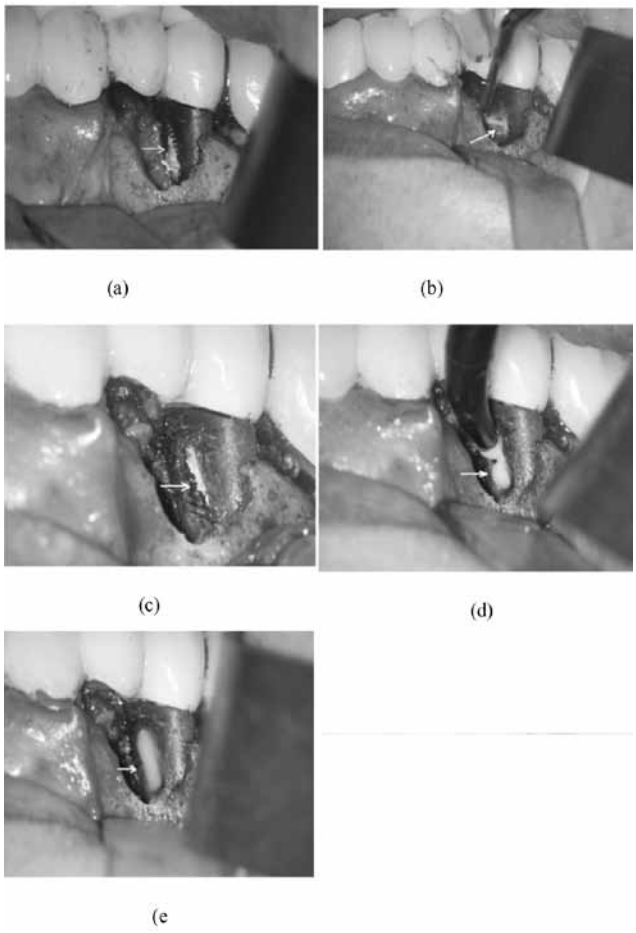


Fig7(a) perforated region sealed with gutta-percha after retrieval of the post; (b) ultrasonics used to prepare a cavity to seal the perforation; (c) cavity prepared; (d) cavity sealed with light cured GIC; (e) restored cavity.

c. Hard tissue management of vertical root fracture and cracks:

The clear distinction can be only made between the cracked tooth and the vertically fractured tooth after the flap has been raised. If there is only presence of simple cracks without damage to the periodontium, methylene blue dye can first be applied to get clear vision of the crack line, then the conservative management of these cracks can be done with small cavity preparation along the cracked line with high speed hand piece or ultrasonic root end preparation tips and the cavity filled with flowable composite resins or glass ionomer cements21.

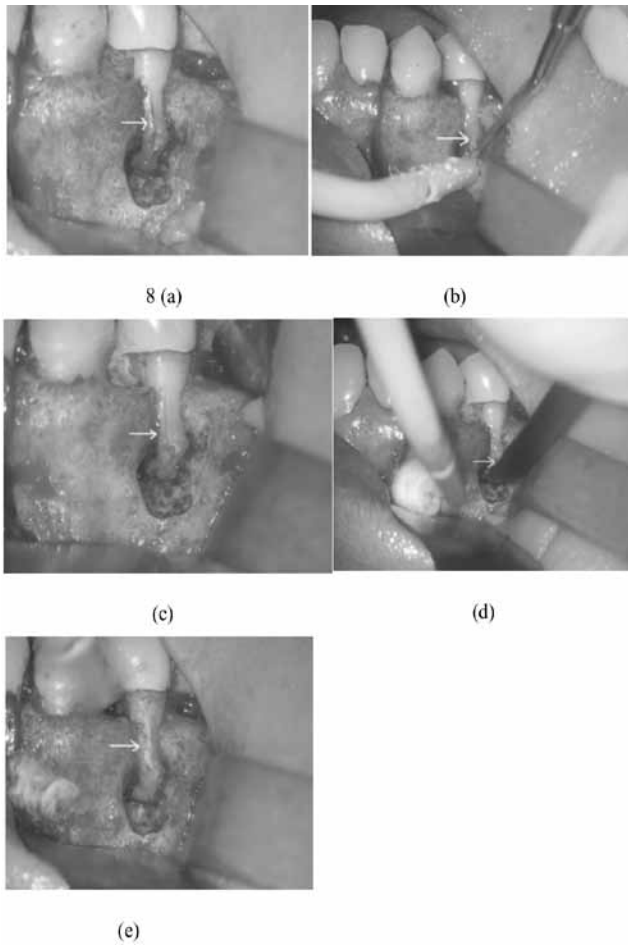


Fig 5(a) vertical root crack indicated by methylene blue stain; (b) cavity prepared with ultrasonics for repair; (c) prepared cavity; (d) defect repaired with light cured GIC; (e) repaired vertical root defect with GIC.

If there is presence of vertical root fracture, then the treatment is difficult and depends upon the extent, duration and direction of the fracture line (if it is mesiodistal or buccolingual). In cases of single rooted teeth, the prognosis is comparatively poor and treatment depends upon the removal of the fractured fragments. If the fractured fragment is easily removed, then the remaining of the root structure is repaired with biocompatible material21. Prognosis for multirooted teeth is often good and can be successfully treated either by root amputation or hemisection[7].

Localized Hemostasis and Placement of the restorative materials:

Localized hemostasis throughout the periradicular surgery plays an important role for the successful outcome after the surgery. Good hemostasis controls blood loss, minimizes surgical time, and

reduces postoperative blood loss and swelling[18]. It also provides better visibility, and a suitable environment for the placement of the restorative material. Following sequence is recommended for hemostasis during endodontic micro surgery.

Pre-surgical: Local anesthetic agent with epinephrine can be injected as multiple infiltrations in the buccal/labial or palatal surfaces around the surgical field. E.g. 2% lidocaine with epinephrine. Before the first incision is made, at least 15-20 minutes should be waited for the vasoconstrictive agent to be active and constrict the blood vessels[3].

During surgery:

i) All the granulomatous tissues should be completely removed as these are highly vascularised and bleeds profusely.

ii) A number of different local haemostatic agents can then be applied for hemostasis during surgery. Few of them includes; collagen based materials, ferric sulphate, calcium sulphate or epinephrine soaked cotton pellets [3, 25].

Materials available for repair of root defects:

Many materials have been advocated for the use as root repair materials. Some of which have been used commonly in the past 10 years are zinc oxide eugenol (IRM and super EBA) amalgam, composite resins (retroplast), glass ionomer cements, resin-glass ionomer hybrids (geristore), compomers (dyract), mineral trioxide aggregate (MTA) and Iroot BP.

The material of choice depends upon the site and the type of the root defect present. If the defect is supracrestal, materials such as amalgam or composite can be used. If the defect is subgingival following root caries, external root resorption or perforation defects, then material of choice varies[4]. Recently, most popular are resin- ionomer suspension (Geristore, Dentsply,Tulsa dental) and compomers (Dyract Dentsply , Tulsa dental), both of which combines various properties of composite resins and glass ionomers. Geristore has shown as an adjunct to guided tissue regeneration when used to repair root perforations[37-40].Geristore and dyract are less sensitive to moisture, than conventional glass ionomer cements and hence provides stronger bonds, enhanced by dry environments[41]. Geristore also appears to facilitate regeneration of periradicular tissues[42]. Even though, from the biologic perspective MTA is superior to other materials in regenerating periradicular tissues, but because of its difficult handling properties, it cannot be used as repair materials in all the cases. Class I box shaped cavities are usually preferred for MTA4.

Guided tissue regeneration:

Guided tissue regeneration techniques are based upon controlling the epithelial proliferation by allowing a barrier material between the gingival tissue and the exposed root surface and supporting alveolar bone. This prevents the colonization of exposed root surfaces by gingival cells and proliferation of periodontal ligament cells over the exposed root surfaces, thus preventing formation of deep pockets.

Barriers can be grouped into 2 broad categories as resorbable and non resorbable membranes. Resorbable membranes are more suitable for endodontic surgery as it does not need 2nd surgery for its removal e.g. Bio-Gide (Geistlich, Switzerland). However, these membranes also require a support so that it doesn't collapse into the defect itself. Hence, either a titanium-tented material or graft can be used for the support[43-46]. Also artificial bone can be placed into the bony cavity to enhance rapid bone regeneration eg: Bio-Oss (Geistlich, Switzerland).

Fig 10 (a) Placement of artificial bone (Bio Oss); (b) placement of artificial collagen membrane (Bio gide)

Closure of the surgical site :

Before wound closure, careful examination of the surgical site should be done for presence of any foreign materials. If possible radiographic examination should be also taken prior to the wound closure. Irrigation with sterile saline or water can be done to remove the foreign debris. The flap is then repositioned and sutures

placed. Suture material often used are thinner monofilament with smaller needles of size 5-0 and 6-0. Interrupted or sling sutures can be placed according to the need as shown in fig 11a. In interrupted sutures, the corners are first sutured to provide maximum ease while suturing. After the suturing is complete, post surgical pack is placed if required (as shown in fig 11b)and sterile, chilled, moistened gauze can be placed over the flap, and pressure applied for 5 minutes. The patient is then instructed to hold the ice pack around the surgical site of the face – on for next 20 min and off for the next 20 minutes - and continue to do for the next 24 hour4.

Fig 11(a) Placement of interrupted and sling sutures; (b) Placement of post –surgical pack

Periodic Follow-ups:

With the use of monofilament sutures of size 5-0 and 6-0, first followup can be done after 72 hrs for suture removal as shown in fig12 a and b. This is enough time for reattachment to take place and suture removal becomes easy and painless. After 72 hrs, the mucosal tissue tends to grow over the suture material making the suture removal procedure painful and inconvenient[3, 4]. After suture removal, periodic follow up can be done at a period of 3 months, 6 months, 1 year and so on for the evaluation of the tooth.

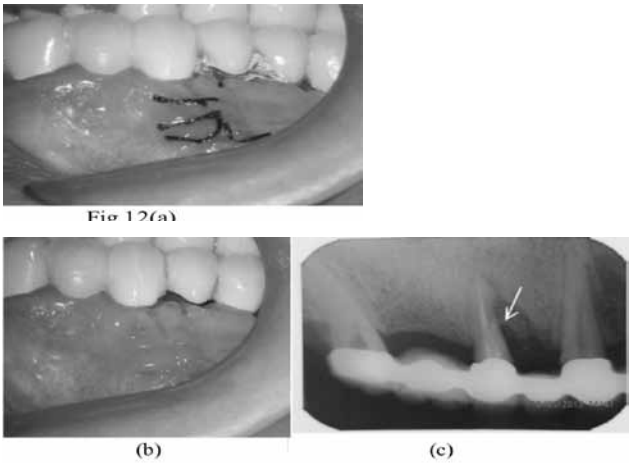


Fig12(a) 1st followup visit before suture removal; (b) After suture removal; (c) Post surgical IOPA indicating area of repair of perforation due to post.

Discussion:

The success and failure after the endodontic microsurgery depends upon multiple factors. Early diagnosis is the most important factor. The size of the lesion, amount of bone damage, location of the defect (whether it is located bucally/palatally) plays a vital role. The periodontal status of the tooth is also significant. Also, the healing capacity of the patient is also equally important.

In External root resorption, the amount of the root resorption determines the prognosis. Similarly, in perforation the site of the defect whether it is located buccally or palatally is significant. In cases of vertical root fracture, multirooted teeth can be successfully treated by hemisection or root amputation. However, treatment of anterior teeth can be best regarded as experimental.

The cases reported in this review article have shown successful outcomes. But the long term prognosis and success rate is yet to be proven. Also, the cases discussed in this review article still needs further follow-ups and research. If there is endodontic failure , then extraction of tooth followed by its artificial replacement is the last choice of treatment.

Conclusion:

With the advent of endodontic microsurgery and advancements in investigating methods with CBCT, use of microscopes and use of microinstruments, many teeth that were initially indicated for extraction can now be successfully saved. With endodontic microsurgery, almost all teeth with endodontic lesions can be successfully treated. The clinical success of microsurgery over traditional surgery, based on the absence of symptoms and radiographical healing is always high. However, before conserving the tooth with endodontic microsurgery, it should be carefully weighed against extraction and replacement of tooth with denture or implants.

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