21
Adjunctive Procedures

MAHMOUD TORABINEJAD AND MOHAMMAD SABETI

CHAPTER OUTLINE

LEARNING OBJECTIVES

After reading this chapter, the student should be able to:

1. Discuss the role of adjunctive endodontic surgery in patient treatment planning.
2. Recognize situations in which adjunctive surgical procedures are the treatments of choice.
3. Define the terms incision and drainage, root resection, hemisection, crown lengthening, tooth replantation, tooth transplantation, and socket preservation.
4. Discuss the indications for each procedure listed in objective 3.
5. Describe in brief the step-by-step procedures involved in objective 3.
6. Discuss the prognosis for each procedure listed in objective 3.

Introduction

Adjunctive surgical procedures are those that are used to treat either pathologic conditions or mishaps that occur during root canal treatment. One of the pathologic conditions that requires an adjunctive procedure is an incision for drainage for acute apical abscesses. As discussed in Chapter 18, most procedural accidents can be corrected nonsurgically. When nonsurgical correction is not feasible or impractical, these conditions are treated surgically, as discussed in Chapter 20. Adjunctive surgical procedures are additional. So it is additional treatment modalities to treatment modalities prevent tooth loss and preserve natural dentition. The purpose of this chapter is to discuss the indications, contraindications, procedures involved, and prognosis for some of these procedures such as incision for drainage, root resection, hemisection, crown lengthening, tooth replantation, and transplantation. In addition, principles and materials for socket preservation after extraction using regenerative techniques and guided bone regeneration (GBR) will be discussed.

Incision for Drainage

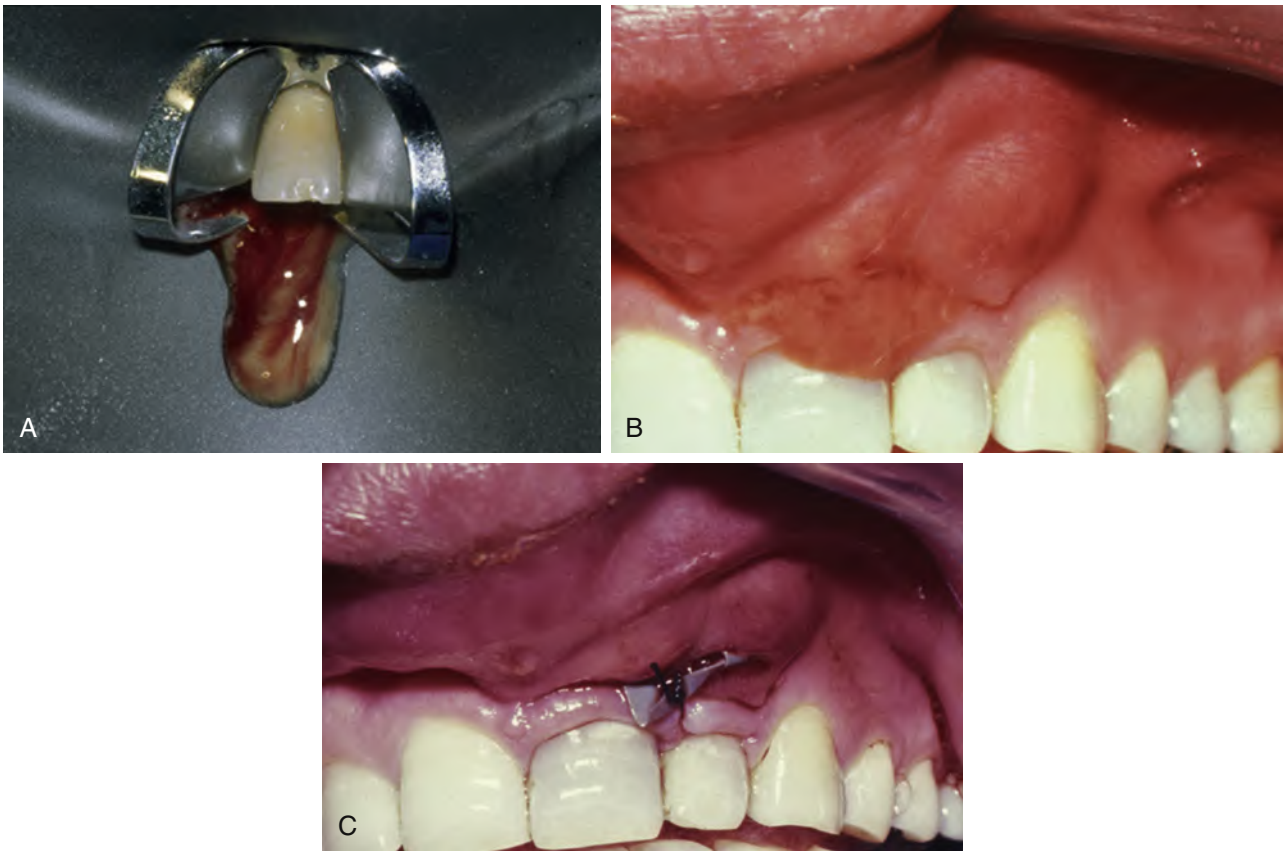
The objective of incision for drainage is to remove inflammatory exudates and purulence from a soft tissue swelling. Incision for drainage reduces discomfort resulting from the buildup of pressure and speeds healing.

Indications

The best treatment for swelling originating from an acute apical abscess of pulpal origin is to establish drainage through the offending tooth (Fig. 21.1, *A*; Video). When adequate drainage cannot be accomplished through the tooth itself, drainage is obtained through soft tissue incision. Drainage through the soft tissue is accomplished most effectively when the swelling is fluctuant. A fluctuant swelling is a fluid-containing mass in which a wavelike sensation is felt when pressure is applied (Fig. 21.1, *B*). Incising a fluctuant swelling releases purulence immediately and provides rapid relief. If the swelling is nonfluctuant or firm, incision for drainage often results in drainage of only blood and serous fluids. Incision and drainage of a nonfluctuant abscess reduces pressure and facilitates healing by reducing irritants and increasing circulation in the area.

Contraindications

There are relatively few contraindications to the use of incision for drainage. Patients with prolonged bleeding or clotting times or those who are on bisphosphonates must be approached with caution, and hematologic screening is often indicated. An abscess in or near an anatomic space should be handled very carefully.



• **Fig. 21.1** **(A)** Establishment of drainage through an offending tooth. **(B)** A fluctuant swelling is present because of the presence of an infection in the right lateral incisor. **(C)** An incision for drainage is performed and a rubber drain is sutured in place to prevent immediate closure of the incision.

Procedures

Anesthesia

Profound anesthesia is sometimes difficult to obtain in the presence of inflammation, swelling, or exudates. Because direct subperiosteal infiltration is ineffective and may be quite painful, regional block anesthetic techniques are preferred. Mandibular blocks for posterior areas, bilateral mental blocks for the anterior mandible, posterior superior alveolar blocks for the posterior maxilla, and infraorbital blocks for the premaxilla area are the preferred choices. These injections may be supplemented by regional infiltration.

In addition to block anesthesia, one of the following methods may also be used. The first technique is infiltration that starts peripheral to the swelling. After the application of topical anesthetic, the solution is injected slowly with limited pressure and depth, and this is followed by additional injections in previously anesthetized tissue, moving progressively closer to the center of the swelling. This procedure results in improved anesthesia without extreme discomfort.

The second technique is the use of topical ethyl chloride. A stream of this solution is directed onto the swelling from a distance, permitting the liquid to volatilize on the tissue surface. Within seconds, the tissue at the site of volatilization turns white. The incision is quickly accomplished with continued ethyl chloride spray. This topical anesthesia is a supplement to block anesthesia when a quick incision is required. If none of these procedures work, nitrous oxide/oxygen sedation or intravenous (IV) sedation can be used for incision and drainage.

Incision

After anesthesia, the incision is made vertically with a No. 11 scalpel (Fig. 9-6C). Vertical incisions are parallel with the major blood vessels and nerves and leave very little scarring. The incision should be made firmly through periosteum to bone. If the swelling is fluctuant, pus usually flows immediately, followed by blood (Video). If the swelling is nonfluctuant, the predominant drainage is blood.

Drainage

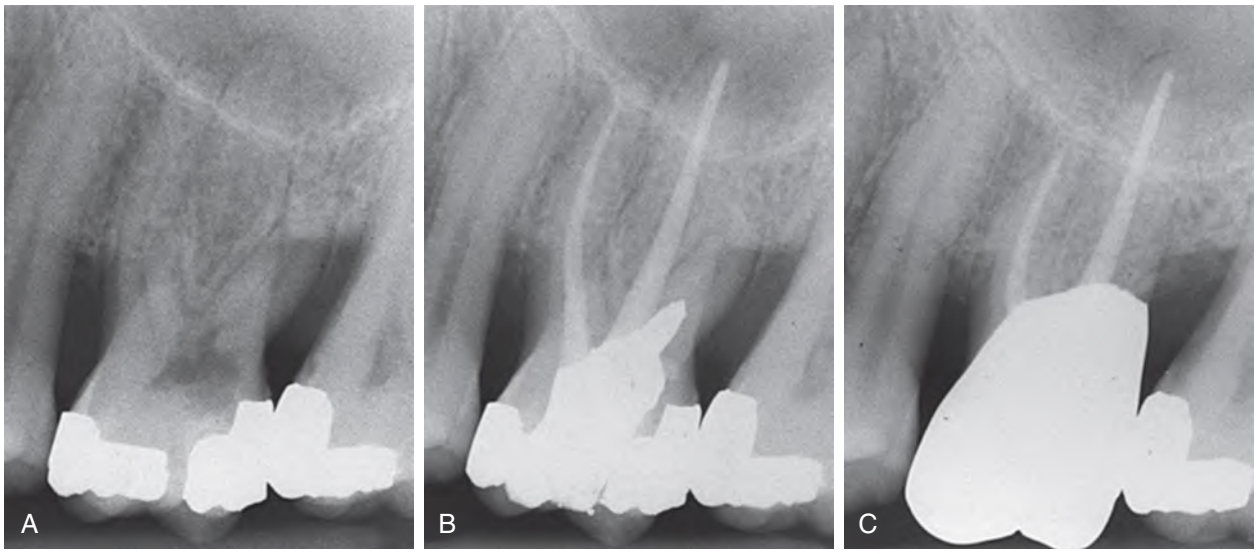
After the initial incision, a small closed hemostat may be placed in the incision and then opened to enlarge the draining tract (Fig. 9-6D). This procedure is indicated with more extensive swellings. To maintain a path for drainage, an I-shaped or "Christmas tree" drain cut from a rubber dam or a piece of iodoform gauze can be placed (suturing is optional) in the incision (Fig. 21.1, C; Video). The drain should be removed after 2 to 3 days; if it is not sutured, the patient may remove the drain at home.

Root Resection

Root resection is removal of the whole or part of a root from any multirooted tooth. This operation is usually performed in maxillary molars, but it can also be done in mandibular molars.[1]

Indications

The main indication for root resection is presence of severe bone loss in a periodontally involved root that cannot be treated by periodontal



• **Fig. 21.2** **(A)** A maxillary molar with severe bone loss around the distobuccal root. **(B)** Root canal treatment was followed by an amalgam core extending 3 to 4 mm into the distobuccal canal. **(C)** The root was amputated, and a crown subsequently placed.

treatment. In addition, root resection is indicated for root(s) of multirooted teeth with severe caries, resorption, vertical root fracture, or untreatable procedural accidents in the furcation of multirooted teeth.

Contraindications

Root resection is contraindicated when there is insufficient bony support for the remaining root(s), patients on bisphosphonates, and in the presence of fused roots.

Procedures

Root resection can be performed with and without a surgical flap. Raising a surgical flap provides better visibility for the operator. After raising a flap, root resection is performed using a fissure bur to cut the involved root and separating it from the crown. The remaining stump should be contoured to the surface of the crown, providing the patient a good hygiene (Fig. 21.2). The prognosis for root resection has been reported as fair to good depending on case selection, patient hygiene, and motivation (Video 21.1).[1]

Hemisection

Hemisection is the surgical division of a multirooted tooth into two segments. It is usually performed in mandibular molars and in rare occasions in maxillary molars. The indications and contraindications for hemisection are similar to those for root resection.[2-6]

Procedures

Like in root resection, hemisection can be performed with and without a surgical flap. After raising a flap, a vertical cut is made through the crown into the furcation using a fissure bur. The initial cut should be made close and at the expense of the unsalvageable root. The tooth is sectioned through the bifurcation. The unsalvageable root is then removed. The anatomic crown of the remaining root(s) should then be contoured to the surface of the root without any ledges. This action provides good, smooth margins for the prosthetic crown and adequate access for good hygiene by the patient (Fig. 21.3). The success rates of teeth that have had root amputation or hemisection has been reported to be 70% to 85%.[3,4] Like root resection, the main factors affecting the long-term success of this procedure are case selection and the patient's oral hygiene (Videos 21.2 and 21.3).[3,5,6]

Crown Lengthening

Although clinicians often prefer supragingival margin placement, some situations like presence of subgingival decay, crown fracture, root perforation, short clinical crown, tooth hypersensitivity, or esthetic demands may dictate subgingival margin for placement of restoration. Placing restoration margins below gingiva can cause persistent gingival inflammation and eventually tooth loss.[7-11] To prevent these complications and establish biological width, crown lengthening can be performed either surgically or nonsurgically. Surgical crown lengthening (SCL) usually consists of removal of soft and/or hard tissues to achieve a longer clinical crown and reestablish the proper biologic width dimensions around a tooth.

Indications

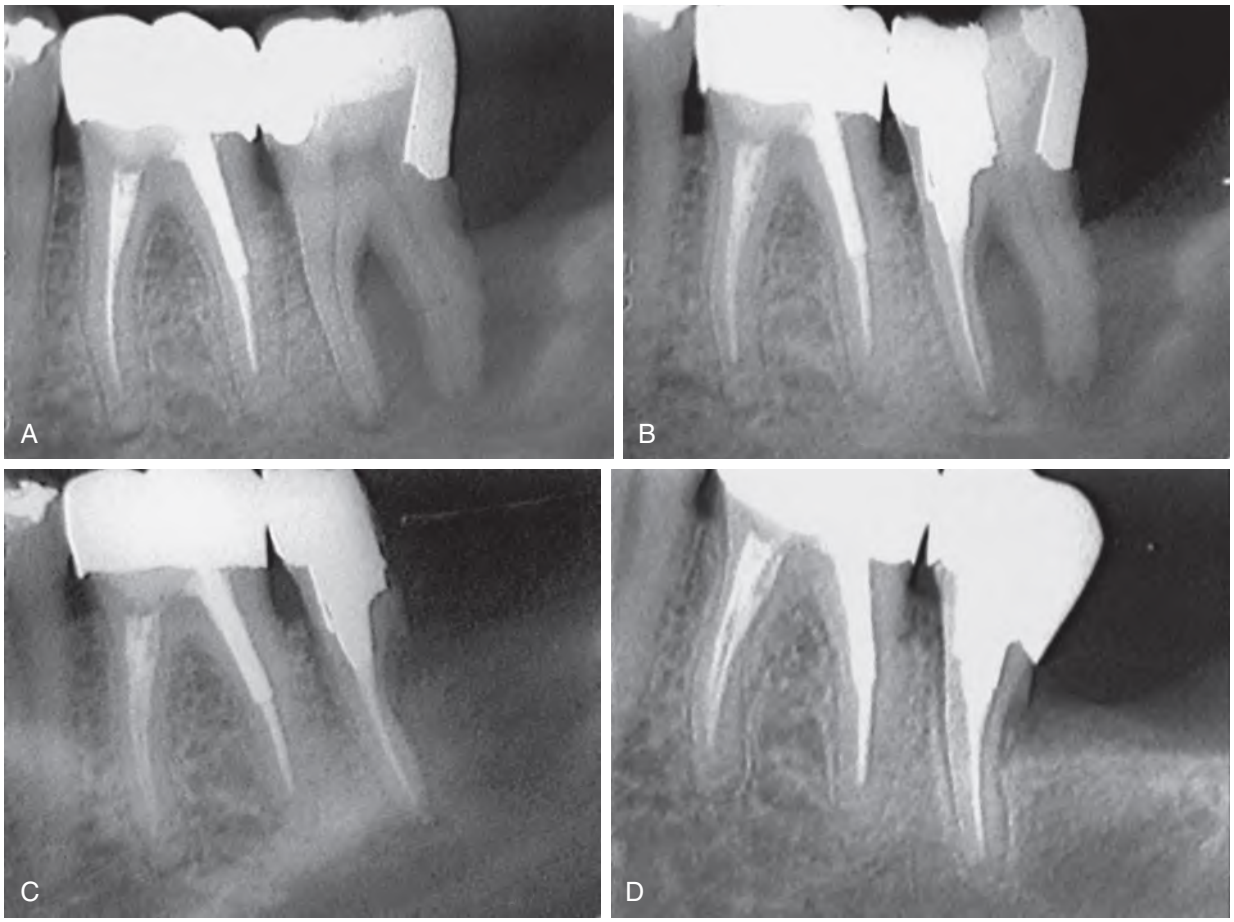
SCL is indicated for teeth with a short natural clinical crown and shortened clinical crown resulting from the presence of pathologic conditions such as extensive decay, resorption, iatrogenic perforation, or crown fracture extending subgingivally.[12-13] SCL is indicated when the operator expects that the final restorative margin will be located less than 3 mm from the alveolar bone crest.

Contraindications

SCL is contraindicated for medical reasons, patients on bisphosphonates, when the procedure could result in exposure of a tooth furcation, or it is near vital anatomic structures such maxillary sinus or mental foramen and for teeth in the esthetic zone, when the procedure results in the presence of a long clinical crown for only one tooth.[13]

Procedures

SCL is typically accomplished by either gingivectomy or placing gingival tissue flap apically with or without bone removal.



• **Fig. 21.3** **(A)** A mandibular second molar with severe bone loss around distal root. **(B)** A postoperative radiograph after root canal treatment on the mesial roots and placing an amalgam core. **(C)** A postoperative radiograph after performing hemisection. **(D)** A postoperative radiograph 2 years later.

After raising a full-thickness flap, a submarginal incision is performed. Then, soft and hard tissues are removed, and the flap is sutured in the appropriate level to allow reestablishment of the epithelial and connective tissue attachment and for allowance of enough tooth structure for adequate support of the planned restoration (Fig. 21.4). The mean survival rates of SCL procedure have been reported at 83% after 10 years.[14] However, a recent systematic review with limited data concludes that SCL can result in increased crown length and possible gingival margin rebound.[15]

Root Extrusion

An alternative to SCL is orthodontic extrusion or forced eruption.[16,17]

Indications and Contraindications

Root extrusion is indicated for any tooth with horizontal crown or root fractures, decay, resorption, or accidental perforations that extend below the crestal bone 0 to 4 mm.[17] The contraindications for root extrusion are short roots, insufficient space to extrude the root, and periodontal disease.[17]

Procedures

If there is enough tooth structure available after root canal treatment, brackets are placed on the incisal third of the crown of the involved tooth and the adjacent teeth. Vertical force is applied to the involved tooth by placing elastic bands on the adjacent teeth and connecting them to the endodontically treated tooth with inadequate coronal structure (Fig. 21.5). When there is not enough coronal tooth structure available, a paper clip is cemented with intermediate restorative material (IRM) in the coronal portion of the root canal treated tooth. After cementing a horizontal wire on the adjacent teeth, vertical force is applied to the involved tooth by placing elastic bands from the paper clip in the root canal-treated tooth and the horizontal wire. Because of light extrusion forces, the tooth and the entire periodontal attachment apparatus will move coronally. This procedure may take 2 to 4 weeks. After accomplishing adequate extrusion, the tooth must be stabilized for at least 2 months before placing a final restoration[17] (Fig. 21.6). This treatment can also be expedited with fiberotomy. When performed, the marginal bone level will mostly stay in the original position.[18]

The disadvantages of orthodontic root extrusion include esthetic issues during the procedure, required time to accomplish ideal results, and surgical fiberotomy after root extrusion. Because of these disadvantages, surgical extrusion (Fig. 21.7) has been suggested as an alternative to crown lengthening by orthodontic extrusion.[19] The surgical extrusion consists of extraction and stabilization of the extracted tooth for 4 to 6 weeks and its concept is based on information from the dental trauma literature regarding treatment of extrusive luxation.

Study Questions

1. The objectives of incision for drainage are:
   a. Remove inflammatory exudates and purulence from a soft tissue swelling
   b. It reduces discomfort resulting from the buildup of pressure
   c. Speeds healing
   d. Increasing circulation in the area
   e. None of the above
   f. All of the above
2. What are the contraindications for incision and drainage?
   a. Patients with prolonged bleeding or clotting times
   b. An abscess in or near an anatomic space should be handled very carefully
   c. Patient with fluctuant swelling and a fluid-containing mass
   d. A and B
3. What are the main indications for root resection?
   a. Severe bone loss in a periodontally involved root that cannot be treated by periodontal treatment
   b. Multirooted teeth with severe caries, resorption, vertical root fracture
   c. Presence of fused roots
   d. A and B
4. What are the contraindications for surgical crown lengthening?
   a. When the procedure could result in exposure of a tooth furcation
   b. Proximity to vital anatomic structures such as maxillary sinus or mental foramen
   c. None of the above
   d. A and B
5. What are the indications for root extrusion?
   a. Any tooth with horizontal crown or root fractures
   b. Any tooth with decay and resorption
   c. Short roots
   d. A and B

Tooth Replantation

Tooth replantation is the reinsertion of a tooth into its own alveolar socket after performing apical surgery out of the socket.[20] This procedure is indicated when an apical surgery is contraindicated or very difficult to perform and is the last treatment option to save a tooth (Fig. 21.8).

There are several factors that affect the clinical success of intentional replantation. They include: age, sex, type of tooth replanted, presence of fractures, stage of root development, status of surrounding alveolar bone, contamination of the replanted tooth, cleansing procedure, and antibiotic therapy.[21]

The apical size (correlated with age) and the length of time the tooth has been out of the socket are, respectively, two of the most important factors to determine prognosis.[22] The success factor for intentional replantation stems from the ability of the replanted tooth to be integrated back into the body in a timely fashion. The timeliness relates directly to the viability of the surrounding mesenchymal cells around the implanted tooth. Teeth that have been dried out have minimal capability to revascularize or regenerate any of the mesenchymal cells in the periodontal ligament or cementum, which are vital for the success of reimplantation.

The adverse effects of replantation include surface resorption and ankylosis; these signs are typically observed within 12 months after replantation.[23] There is a noticeably higher success rate with implant supported crowns than with intentionally replanted teeth: 97% and 88%, respectively.[24] Although the data show much more predictable results with implants, intentional replantation is still considered a reliable procedure and should be considered as a treatment option to patients for those that are seeking to maintain their dentition.[25]

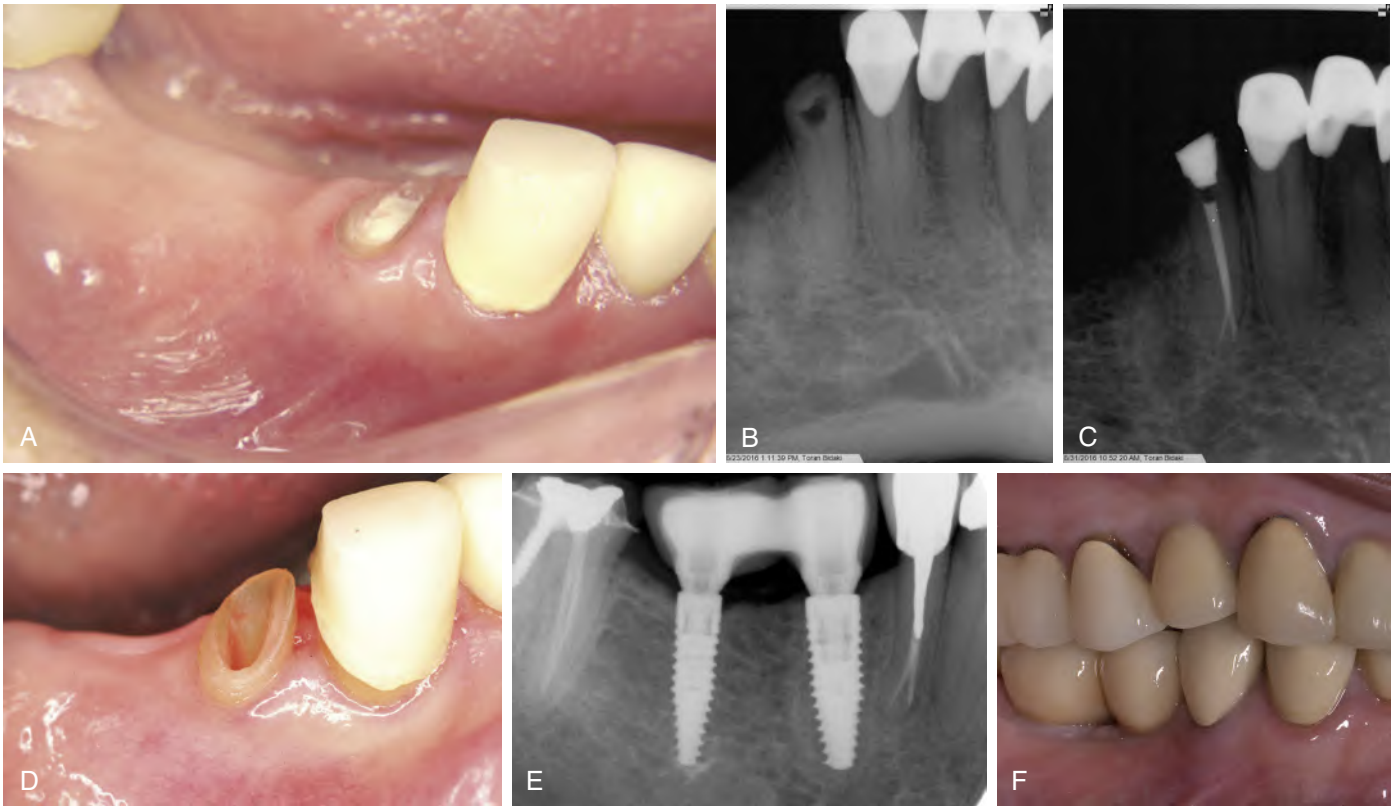
Tooth replantation is contraindicated for teeth that are not restorable, have inadequate bony support, and are difficult to extract. Patients on bisphosphonates may not be good candidates for this procedure. After extracting the tooth with minimal trauma, the apical surgery is performed outside of the mouth and then the tooth is reinserted into its original socket.[24] Tooth replantation has a long history in dentistry.[26] When properly planned and performed, tooth replantation has been shown to be quite successful (mean survival of 88%).

Transplantation

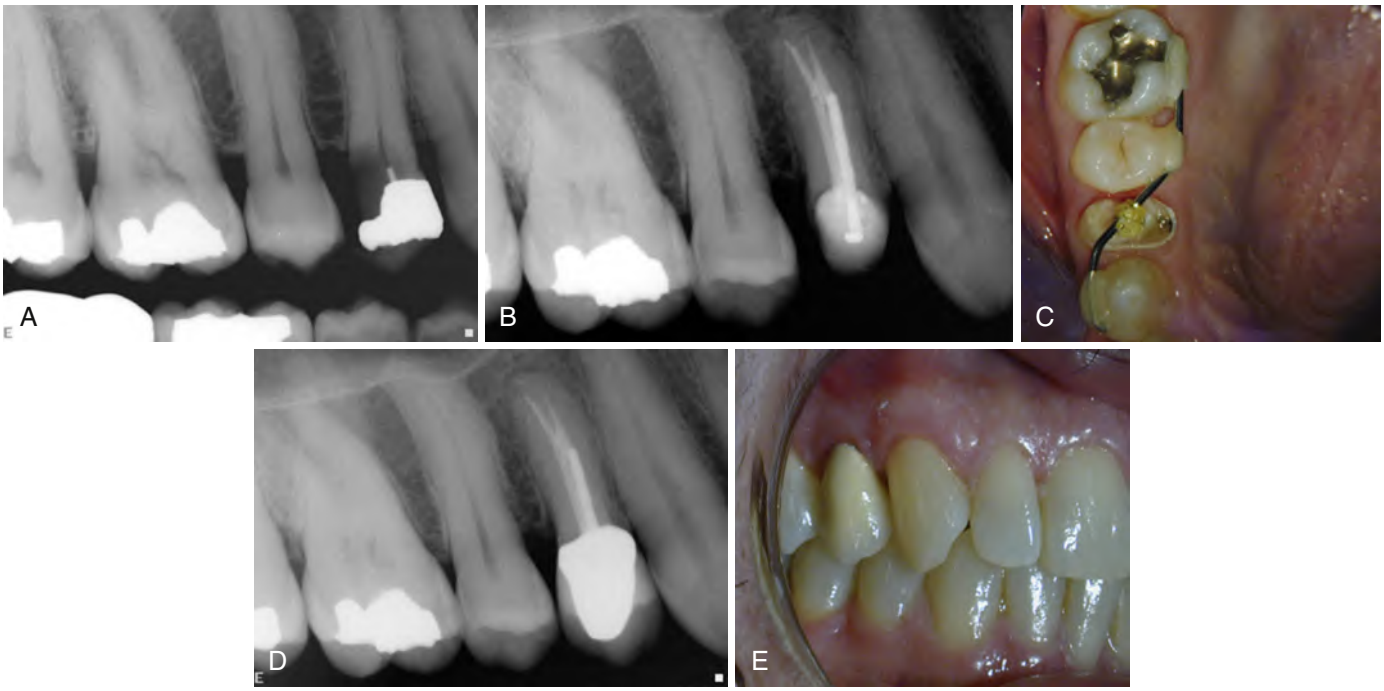
Transplantation is extraction of an erupted, embedded, or impacted tooth from one part of the mouth into an extraction site or surgically prepared recipient site within the same individual.[20] Transplantation of a tooth is indicated for either an unsalvageable or missing tooth.[27,28] It is contraindicated if the transplanted tooth is not restorable, has inadequate bony support, is difficult to extract, and does not fit the recipient site. Patients on bisphosphonates are not be good candidates for transplantation. Ideally, root canal treatment should be performed on the transplanted tooth before this procedure. After extracting the unsalvageable tooth and preparing the socket for transplantation of a new tooth, the extracted healthy tooth is extracted with minimal trauma and damage to the periodontium. An apical surgery is performed on the extracted tooth outside of the mouth, and then the tooth is reinserted into its new socket (Fig. 21.9). During tooth transplantation, the tooth must be kept in moist gauze to prevent dehydration and necrosis of the periodontal ligament. When appropriately indicated and performed, transplanted teeth have a good prognosis.[28]

Guided Tissue Regeneration and Guided Bone Regeneration in Endodontics

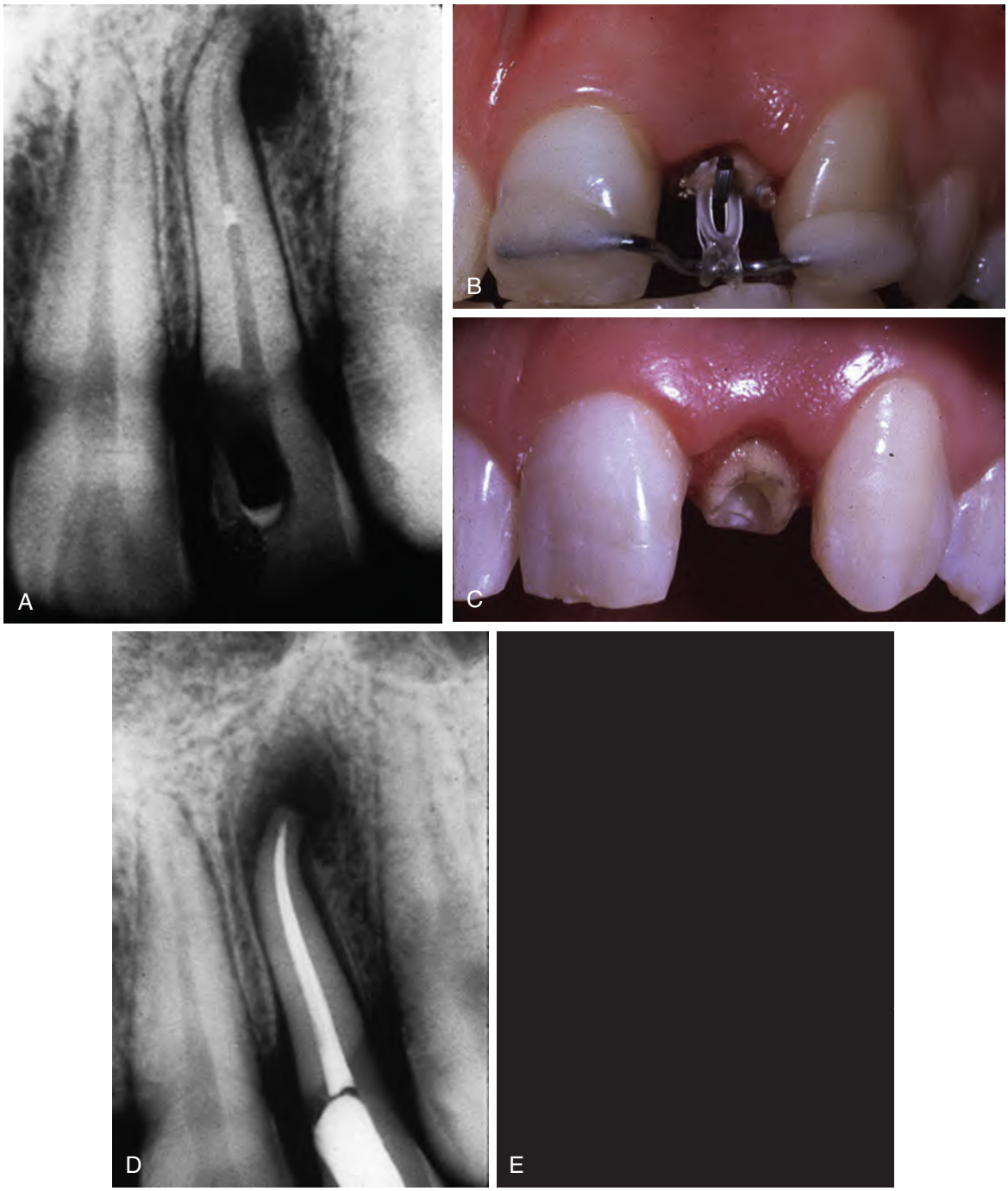
Guided tissue regeneration (GTR), as a technique, follows from observations that the type of tissue that forms the attachment to an exposed root surface is a result of the types of cells that first populate the area.[29] A long junctional epithelium will form from advancing epithelial tissues, root resorption may occur from advancing gingival connective tissue, resorption and ankylosis follows from bone in contact to the root surface and, finally, if periodontal ligament (PDL) cells propagate, a connective tissue attachment may form. As an ideal outcome, PDL cells will lead to an appropriately oriented new connective tissue attachment and subsequent bone formation. Early studies showed that preserved PDL tissues on the extracted teeth of dogs auto-implanted into areas of the jaw promoted healing, and thus a functionally oriented connective tissue attachment. In practice, GTR is often used for cases where periodontitis has led to significant clinical attachment loss. With the addition of bone grafting, GBR can be used in concert with GTR to fill bony defects. Generally, after surgical exposure of the areas of clinical attachment loss with a bony defect and débridement of the exposed root surface, bone grafting material is placed with a barrier to prevent the apical migration of gingival epithelium and the formation of gingival connective tissue, root resorption, or ankylosis. Thus PDL fibers will be allowed to form a proper connective tissue attachment with alveolar bone filling in the space.[30] It is worth noting that epithelial derived cells migrate up to 10 times faster than other periodontally derived cells, thus these types of cells must be prevented from apical migration by use of a barrier to allow the cells with regenerative potential (the PDL cells) to proliferate.[31]



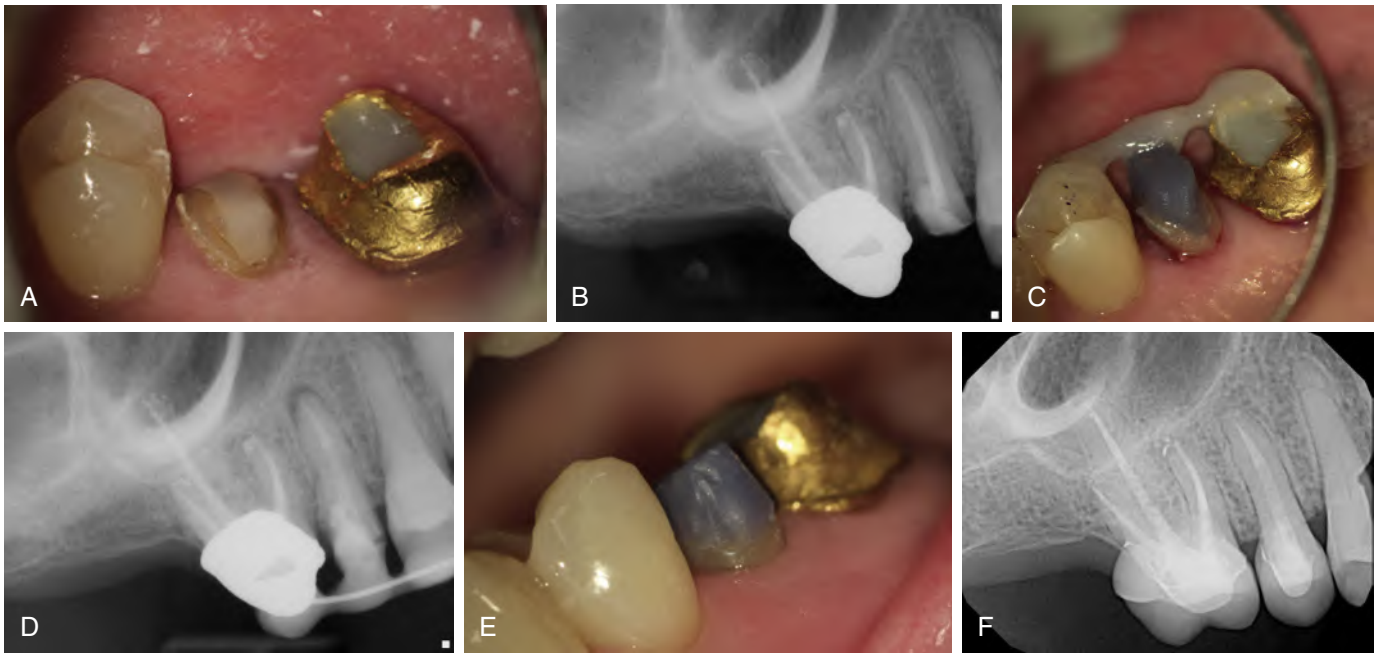
• **Fig. 21.4** **(A)** Clinical appearance of mandibular first premolar tooth requiring crown lengthening surgery. **(B)** A preoperative radiograph of the same tooth showing presence of adequate root canal treatment. **(C)** A postoperative radiograph after root canal treatment. **(D)** A postoperative clinical appearance of the same tooth after crown lengthening procedure. Note increase in supragingival tooth structure compared with **A**. **(E)** Postoperative radiograph after restoration of that tooth with post and a crown and placement of two implants in the edentulous area. **(F)** A postoperative clinical appearance of the region after restoration. (Courtesy of Dr. Brian Goodacre.)



• **Fig. 21.5** **(A)** A preoperative radiograph of a maxillary first premolar with an inadequate clinical crown for restoration. **(B)** A radiograph showing completed root canal treatment on this tooth. **(C)** A clinical photograph of placement of extrusion apparatus to extrude the tooth orthodontically. **(D)** A postoperative radiograph after extrusion of this tooth. **(E)** Postoperative radiograph after root canal treatment, extrusion, and placement of a crown 15 months after completion of the procedures. (Courtesy of Dr. M. Pouresmail.)

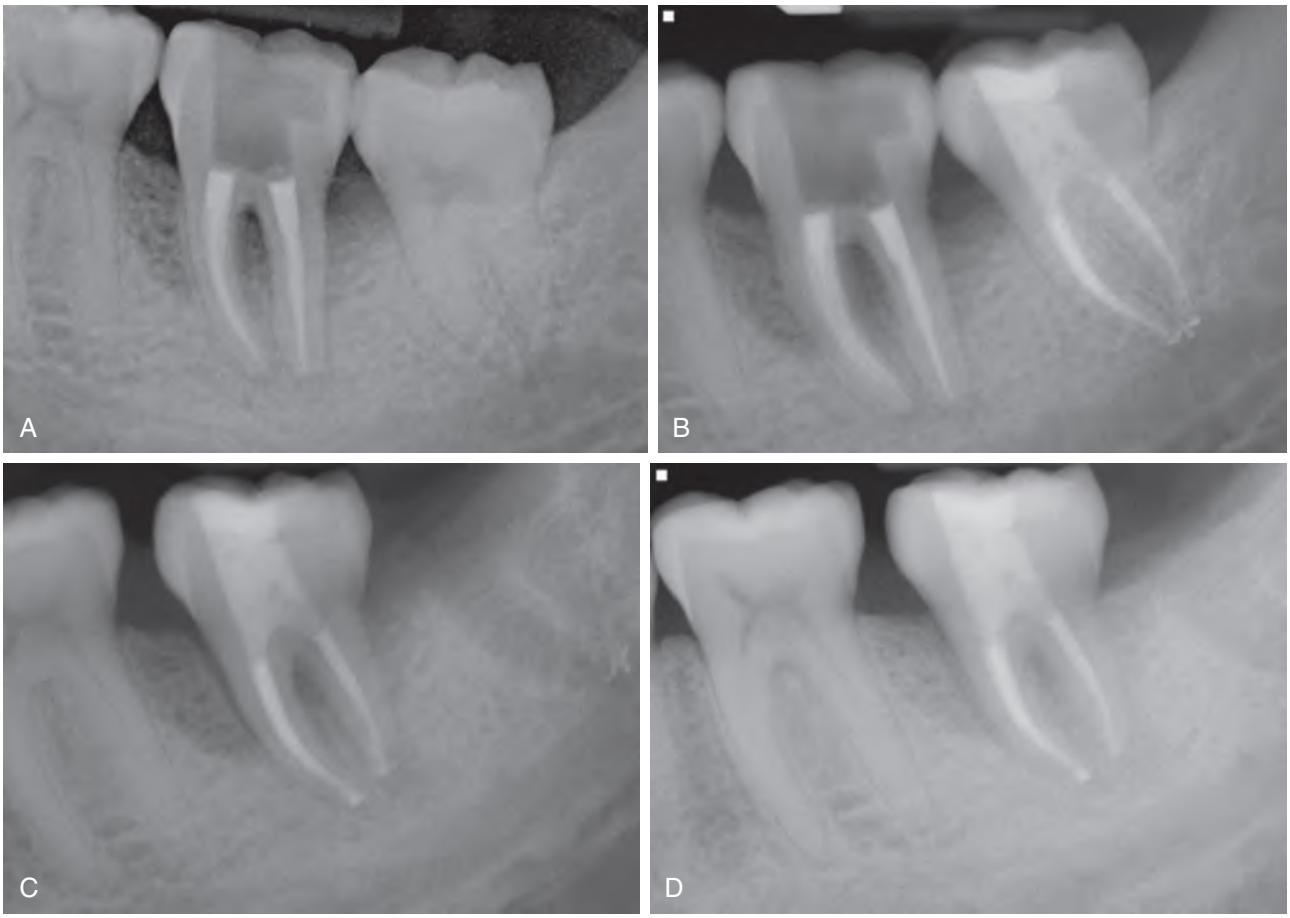


• **Fig. 21.6** **(A)** A preoperative radiograph of a maxillary lateral incisor with severe cervical decay with an inadequate clinical crown for restoration. **(B)** After completing root canal treatment, a paper clip is cemented with intermediate restorative material (IRM) in the coronal portion of the root canal treated tooth. After cementing a horizontal wire on the adjacent teeth, vertical force is applied to the involved tooth by placing elastic bands from the paper clip in the root canal treated tooth and the horizontal wire. **(C)** Because application of light extrusion forces for 4 weeks has resulted in the movement of the tooth and the gingiva, a gingivectomy has been performed to expose the root completely. **(D)** A postoperative radiograph after extrusion of this tooth. **(E)** A postoperative radiograph after root canal treatment, extrusion, and placement of a crown 15 months after completion of the procedures.



• **Fig. 21.7** **(A)** A preoperative photograph of a maxillary second premolar with an inadequate clinical crown for restoration. **(B)** A radiograph showing this tooth has adequate root canal treatment. **(C)** A clinical photograph of this tooth after surgical extrusion and splinting it to the adjacent teeth. **(D)** A postoperative radiograph after extrusion and splinting of this tooth. **(E)** A clinical photograph of this tooth 3 weeks later. **(F)** A postoperative radiograph after extrusion and placement of a crown 4 months after completion of the procedures. (Courtesy of Dr. Rajiv Patel.)

• **Fig. 21.8** **(A)** Preoperative radiograph of a second mandibular molar with a completed root canal treatment with continuous pain. **(B)** A postoperative radiograph after nonsurgical retreatment. The patient remained symptomatic. **(C)** Immediate postoperative radiograph after tooth replantation. **(D)** A postoperative clinical views of the roots after root resection and root end filling with mineral trioxide aggregate (MTA). **(E)** A postoperative radiograph taken 2 years later. The tooth had no clinical symptoms at this time.



• **Fig. 21.9** **(A)** Preoperative radiograph of a nonrestorable mandibular second mandibular molar with vertical root fractures. Radiographic and clinical examinations showed presence of a third intact tooth suitable for transplantation. **(B)** A postoperative radiograph after completion of root canal treatment on the third molar. **(C)** Immediate postoperative radiograph after tooth transplantation. **(D)** Postoperative radiograph seven and half years later shows excellent healing. The tooth had no clinical symptoms at this time.

Rankow et al. listed endodontic clinical applications where GTR may be beneficial. A survey of members of the American Association of Endodontists in 2011 showed that 10.1% of respondents would use GTR for repair of small (<1 cm) periapical lesions, 62.9% for repair of large (>1 cm) periapical lesions, 63.9% for furcation or root perforation repair, and 88.7% for repair of through-and-through (transosseous) lesions.[30] In a review by Corbella et al., studies using GTR with a barrier membrane for endodontic surgery were categorized based on two classification systems.[32,33] Guidelines for the management of the surgical site when using GTR are available.[34]

Indications

It was noted that GTR used for treatment of large periapical lesions may be of some benefit, as well as for through-and through periapical lesions. The use of resorbable membrane barriers showed more favorable outcomes over nonresorbable membranes or the use of a graft without membrane.

Contraindications

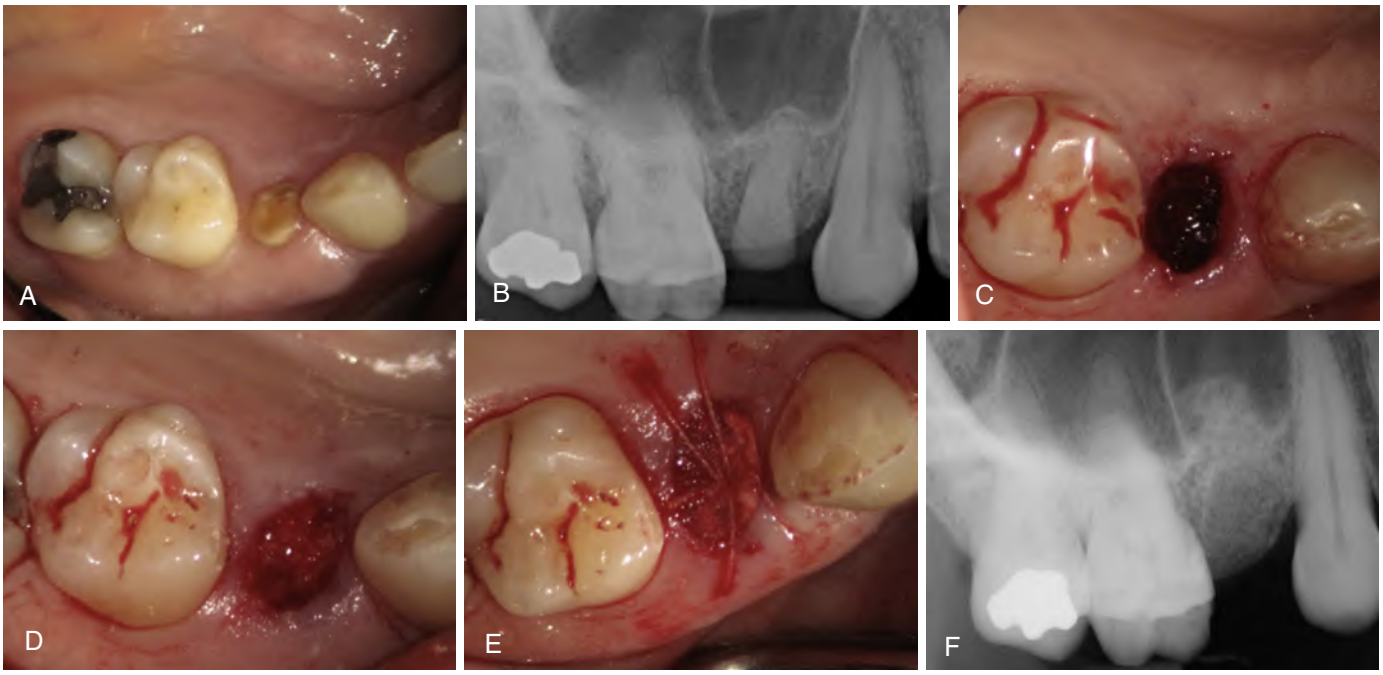
Potential contraindications for endodontic surgery are no different from any elective dental treatment.[34] Case selection should consider the potential for improvement with the proposed treatment versus alternative treatments, evaluation of the patient's medical condition, general oral health, and medication use. Contraindications have been suggested for the use of GTR techniques and include any medical condition incompatible with the procedure, active infection at the site, and poor oral hygiene. Additionally, relative contraindications were suggested for improper interproximal bone level, inadequate tissue thickness, inadequate amount of keratinized gingiva, improper vestibular depth for flap advancement, and smoking.[35] Similar contraindications and relative contraindications were given for GBR techniques used for root coverage in patients with gingival recession.[36] It is important to note that active infection at the site will likely be present when using GTR/GBR techniques during endodontic surgery, but that ideally the source of the infection is removed.

Procedure

In brief: restorable membranes should be used in order to prevent a second surgical procedure to remove the membrane. The membrane should extend 2 to 3 mm past the margins of the bony crypt and supported with the bone graft material. The membrane should be entirely covered when suturing the tissue, and postoperative compression is contraindicated. Additionally, smoking should be avoided as it has been shown to significantly affect a positive outcome.

Prognosis

Prognosis of endodontic surgery on Classes A to C is very good, as studies have shown positive outcomes above 96%. Classes D to



• **Fig. 21.10** **(A)** A clinical view of a second maxillary premolar with severe decay and an inadequate crown for proper restoration. **(B)** A radiograph showing absence of inadequate root and crown restoration to preserve this tooth. **(C)** A clinical picture demonstrating extraction site. **(D)** A clinical picture showing placement of graft material in the socket of extraction site. **(E)** A clinical picture showing placement of resorbable membrane and sutures over the graft material to hold it in the extraction site. **(F)** A postoperative radiograph showing completed socket preservation at the site of extraction.

F represent more challenging cases in which endodontic surgery alone may have a reduced prognosis but, with GTR and/or GBR techniques, the prognosis may be improved.

Socket Preservation

Socket preservation is the procedure used to maintain bone volume after an extraction of a tooth. Generally, bone volume will decrease as a result of resorption processes after a tooth is extracted. The socket preservation procedure is used to minimize this effect and generally involves placement of a biomaterial in the socket in order to delay the resorption process.

Indication

Indications for socket preservation include delayed placement of implants that require the need for reducing bone resorption process, as well as any patient needs that require the need for bone to be sustained. Socket preservations are typically performed with autografts, allografts, xenografts, or alloplasts.

Contraindications

Contraindication to socket preservation include acute infections/medical conditions that may affect proper healing.[37] Patient with uncontrolled diabetes, ongoing radiation therapy, and heavy smokers are also in the contraindications category as poor candidates for socket preservation because of their poor healing capability.[38] Patients with allergies to socket preservation graft material, more specifically synthetic material, are also obviously contraindicated for this procedure.

Procedure

Socket preservation first begins by extracting a tooth. Once the tooth has been extracted the chosen graft material is placed into the socket and the wound is sealed with primary closure[39] (Fig. 21.10).

Study Questions

6. What cells travel faster than other periodontal derived cells?
   a. Epithelium
   b. Connective tissue
   c. Both
7. Does a barrier prevent periodontal derived cells from apical migration?
   a. Yes
   b. No
8. What are the contraindications for GTR and GBR in endodontics?
   a. Any medical condition incompatible with the procedure
   b. Active infection at the site
   c. Poor oral hygiene
   d. All of the above
   e. None of the above
9. Which of the following are recommended in GTR and GBR in endodontics?
   a. The membrane should extend 2 to 3 mm past the margins of the bony crypt and supported with the bone graft material
   b. The membrane should be entirely covered when suturing the tissue
   c. Use a restorable membrane
   d. All of the above
10. What is the indication for socket preservation?
    a. Delayed placement of implants that require the need for reducing bone resorption process
    b. Any patient that requires the need for bone to be sustained
    c. None of the above
    d. A and B

ANSWERS

Answers Box 21

1 f. All of the above
2 d. A and B
3 d. A and B
4 d. A and B
5 d. A and B
6 a. Epithelium
7 a. Yes
8 d. All of the above
9 d. All of the above
10 d. A and B

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