The use of calcium sulphate in the surgical treatment of a 'through and through' periradicular lesion

G. Pecora[1]*, D. De Leonardis[2]*, N. Ibrahim[3], M. Bovi* & R. Cornelini†

[1]University of Pennsylvania, Philadelphia, Pennsylvania; [2]University of Miami, Miami, Florida; and [3]Case Western Reserve University, Cleveland, Ohio, USA

Abstract

Pecora G, De Leonardis D, Ibrahim N, Bovi M, Cornelini R. The use of calcium sulphate in the surgical treatment of a 'through and through' periradicular lesion. *International Endodontic Journal*, **34**, 189–197, 2001.

Aim This randomized, controlled, clinical study was designed to evaluate the adjunctive effect of calcium sulphate grafts on the surgical treatment of through and through periradicular lesions.

Methodology Twenty patients each with one tooth showing evidence radiologically of a periradicular lesion wider than 10 mm, with lack of both buccal and lingual cortical bony plates and an indication for surgery were selected for the study. Ten teeth were treated with apicectomy, root-end filling and grafting of the bone defect with calcium sulphate prior to suturing (test group). The other 10 teeth received the same surgical therapy but no grafting with calcium sulphate (control group). The outcome of the healing process was evaluated at 6 and 12 months radiographically following the criteria reported by Rud and Andreasen.

Results At the six- and 12-month evaluation the test group had seven teeth with complete healing and two with incomplete healing, whilst the control group showed three teeth with complete healing, five with incomplete healing and one with unsatisfactory healing. One tooth in each group had to be extracted because of a vertical fracture that occurred during the follow-up period.

Conclusions The results of the study demonstrate that the addition of calcium sulphate as a bone graft during the conventional surgical treatment of through and through lesions improves the clinical outcome. Histological analysis is desirable to investigate the quality of tissues formed using the two surgical procedures.

Keywords: bone grafting, calcium sulphate, periraducular surgery, through and through periradicular lesion.

Received 10 February 1999; accepted 11 April 2000

Introduction

Periodontal regeneration after periradicular surgery results in the restoration of the attachment apparatus, namely, cementum, alveolar bone and periodontal ligament (Caton & Greenstein 1993). The application of the principles of guided tissue regeneration (GTR) to endodontic surgery has been the focus of several clinical trials and experimental research both in humans and animals (Pecora *et al.* 1997, Dahlin *et al.* 1990, Diggins *et al.* 1994). Many factors influence the result of the healing process following surgery, in particular, the factors considered as essential to achieve periodontal regeneration are: bacteria tight seal of root-end filling, dentine bio-modification (Lowenguth & Bliedent 1993), wound stabilization (Garret & Bogle 1993), cell migration (Blumenthal & Singiser 1993) and blood supply.

As far as cell migration is concerned, the colonization of the healing wound by periodontal progenitor cells is a prerequisite for the formation of new cementum, a new periodontal ligament apparatus and new alveolar bone

Correspondence: Dr Dario De Leonardis, Viale Africa 2, Rome 00144, Italy (fax: +39 6 5917560; e-mail: d.deleonardis@libero.it).

*G. Pecora, D. De Leonardis and M. Bovi are in private practice in Rome, Italy. Bovi is an active member of Group for Implant Research (G.I.R.).

†R. Cornelini is in private practice in Rimini, Italy.

on a previously diseased root surface (Nyman *et al.* 1982). In order to achieve such results, barrier techniques may be used. Blumenthal & Singiser (1993) reported that horizontal grooves placed on the root surface from mesial to distal may help to improve the migration of periodontal ligament cells into the central area of the lesion.

To understand regeneration of the periodontal structures, it is useful to recall the basic concepts of repair as well as regeneration. Repair occurs when the healing process results in the formation of new tissue with cells and structures that have the ability to react differently from the original ones. Regeneration takes place when the previous existing tissue, damaged by pathology, is replaced by a new tissue identical to the former in cell composition, structure and reactivity. In endodontics, as in periodontics, this implies the formation of new bone, new periodontal ligament and new cementum, i.e. new attachment formation.

A series of animal and human histological studies has shown that conventional periodontal surgery results primarily in repair rather than regeneration of the periodontium (Listgarten & Rosenberg 1979, Caton *et al.* 1980). On the contrary, periodontal regeneration can be achieved predictably by the use of a barrier membrane both in animals (Nyman *et al.* 1982, Caffesse *et al.* 1988) and in humans (Nyman *et al.* 1983, Gottlow *et al.* 1984).

In a similar manner, Dahlin *et al.* (1990) demonstrated that periapical defects and mandibular cyst-like cavities in monkeys healed with virtual complete bone fill, only when treated with a barrier for guided tissue regeneration. On the other hand, the sites treated with conventional surgery only, even though there was some peripheral healing, showed extensive fibrous connective tissue fill. This indicates that in endodontic surgery, especially for large defects or 'through and through' lesions, the action of the periosteum alone (when actually present) may not be sufficient to ensure complete healing. One should also keep in mind that, when a large endodontic lesion is present, it is usually chronic, and often associated with a fistula. Since the periosteum is often damaged in such cases this enhances the chance of unreliable repair (connective tissue scar).

From the biological standpoint, the formation of a new attachment apparatus may offer some advantages compared with generic repair. These include more resistance to bacterial penetration as well as enhancing the resistance to occlusal loads. The quality of healing and the prognosis of the tooth are also affected by the location of the lesion. In fact, the prognosis will vary if, after surgery, the lesion remains in the apical area or is located at the middle third of the root, or there is an endo-perio-marginal communication. With the latter a more complex and less predictable regeneration is expected. Unfortunately, the marginal area is where (for both biomechanical and microbiological reasons) a new attachment apparatus is most needed. Whereas a tooth may well survive with the apex surrounded by connective tissue, an improperly healed endo-perio-marginal lesion will permit recurrent infection and bone loss. Tooth function is biomechanically related to the crown: root ratio. After endodontic surgery it is important to consider not only the length of the root but how much of it is covered by a ligament functionally attached to the supporting bone.

The clinical indications for guided tissue regeneration in endodontics are as follows: large bony lesions (Pecora *et al.* 1995), 'through and through' lesions (Pecora *et al.* 1997), endo and furca lesions (Diggins *et al.* 1994), endo-perio-marginal communications and perforations (Goon & Lundergan 1995).

One critical step in regenerative surgery is the creation and maintenance of a space underneath the membrane. When the use of a membrane is not able to ensure maintenance of such a space, then a material, used as a space maintainer, may be useful. In order to accomplish this, several materials are used: demineralized freeze dried bone allografts, hydroxylapatite, autologous bone, and calcium sulphate (Sottosanti 1992a, Brunsvold & Mellonig 1993).

Calcium sulphate has a long history of safe use in medicine and its use has recently been applied in dentistry because of its potential applications in guided tissue regeneration (Coetzee 1980, McKee & Bailey 1984, Sottosanti 1992b).

Calcium sulphate, under certain circumstances, may act as a filling material and a barrier simultaneously (Pecora *et al.* 1997).

The aim of the present study was to demonstrate the clinical effectiveness of calcium sulphate to act as a barrier and filling material for the treatment of 'through and through' bony lesions.

Materials and methods

Twenty patients with an average age of 48 years (range 30–60) were enrolled in this study. They were in good physical health, nonsmokers and showed the following characteristics:

1 previous root canal treatment and retreatment (except two cases) with persistence of a bony lesion

2 A bone defect wider than 10 mm with lack of both buccal and lingual plates. The lack of two cortical plates was diagnosed preoperatively by periapical radiographs, finger palpation and bone probing

3 All the patients presented with fistula tracts and recurrent episodes of purulent discharge

4 All the cases received conventional root canal retreatment (except two). After a minimum follow-up of 3 months, if the lesion had remained unchanged, the patient was scheduled for the periradicular surgery and included in the present study

Informed consent was received from all patients.

Surgical technique

The 20 cases were randomly assigned by 'flipping a coin': 10 to the test group and 10 to the control group prior to surgery (the two without retreatment were assigned one to each group).

The test treatment consisted of conventional apicectomy and root-end filling, with Super EBA cement (STAILINE, Staines, UK) under magnification with an operating microscope (KAPS SOM 62 with manual zoom; Karl Kaps Gmbh and Co, Asslar, Germany) and filling of the 'through and through' bony lesion with at least three layers of calcium sulphate (Surgiplaster, Class Implant, Rome, Italy). Briefly, after reflection of a full thickness flap, and thorough degranulation of the bony defect, the apicectomy and root-end filling were performed. Special care was taken in preparing a thick mix of calcium sulphate by adding as little liquid as possible to simply wet the powder and achieve a putty-like consistency. A first layer of calcium sulphate was delivered to the cavity and compressed with a dry gauze. This improved haemostasis and provided a relatively dry environment for the following layers. The control treatment consisted of conventional apicectomy and root-end filling only. Two operators, both unaware of which group the operating sites belonged to, performed all the surgeries. After performing the conventional surgical technique (i.e. apicectomy and root-end filling), they were given an envelope which disclosed what group the site they were operating on belonged to. Whilst one operator was performing the surgery, the second prepared the calcium sulphate and filled the bony defects.

The following operative protocol was rigorously applied:

1 full mouth scaling, plaque removal and patient instructions for oral hygiene procedures

2 preoperative mouth-rinse with a 0.12% chlorhexidine-based mouthwash (Parodontax, Chlorhexidine 012, Stafford Miller, Milan, Italy) for 1 min

3 local anaesthesia with xylocaine 2% with adrenaline 1 : 50.000 (Astra Pharmaceuticals, S.p.A., Milan, Italy)

4 buccal intrasulcular incision including one tooth mesial and one distal to the lesion, and two slightly oblique releasing incisions

5 debridement of the bony lesion

6 planing of the exposed roots with curettes and periobus (Ellman Co, Hewlett, NY, USA)

7 root resection removing approximately 2 mm of the root apex with a handpiece Impact air 45 TM (Excellence in Endodontics, Chula Vista, CA, USA). The cut surface was angled no more than 10° toward the buccal plane

8 preparation of a 3-mm deep cavity for root-end filling with ultrasonic device and 'Carr tips' (Excellence in Endodontics, Chula Vista, CA, USA)

9 irrigation with tetracycline solution (100 mg tetracycline mL^{-1} saline) for 3 min at 40 °C, following apicectomy and preparation of the cavity for root-end filling

10 haemostasis was achieved by the application of a 21% ferric sulphate solution (Stasis, Gingipak, Belport Co., Camarillo, CA, USA) and the use of an electrocautery unit (Dento-Surg 90, Ellman, Hewlett, NY, USA)

11 root-end filling with Super EBA and elimination of the scattered material particles under the control of the operatory microscope (12–16 × magnification)

12 only for test sites: filling of the bony lesion with medical grade calcium sulphate in various layers. Each layer was obtained by placing and compressing with a dry gauze a small amount of calcium sulphate mixed to a putty-like consistency. This was repeated until the defect was full. The outer layer was hardened with a fast-setting solution (a potassium sulphate solution). In the control sites nothing was applied and the bone lesion was allowed to fill with the blood clot

13 sutures and closure. Sutures were removed after 1 week

14 antibiotic cover with Amoxicillin and clavulanic acid (neo-Duplamox, Procter and Gamble, Rome, Italy) 1 gm twice a day for seven days

15 patient motivation and reinforcement of oral hygiene. Chlorhexidine mouth-rinse was carried out for for 2 weeks postoperatively

16 a radiographic examination was performed prior to surgery, immediately after surgery and 6 and 12 months following surgery. Radiographs were taken using a long-cone-paralleling technique

Table 1 Results for the two groups (test and control) at 6 and 12 months

	6 months		12 months	
	Test	Control	Test	Control
Complete healing	7	3	7	3
Incomplete healing	2	5	2	5
Uncertain healing	/	/	/	/
Unsatisfactory healing	1[a]	2[b]	/	1
Total	10	10	9	9

[a]Case 6 of the test group was then extracted because of a vertical fracture.
[b]Case 1 of the control group was then extracted because of a vertical fracture.

Surgery was performed by the same operator (PG) under magnification using an operating microscope according to standard principles (Pecora & Andreana 1993, Izawa *et al.* 1994). Another operator (DDL) prepared and placed the calcium sulphate.

The outcome of the healing process was radiologically evaluated, by three independent examiners who were not involved in the surgical procedure and blind with respect to the test or control group, according to the criteria published by Rud *et al.* (1972). That is:

1 complete healing (+ + +)
2 incomplete healing (+ +, scar tissue)
3 uncertain healing (+)
4 unsatisfactory healing (failure).

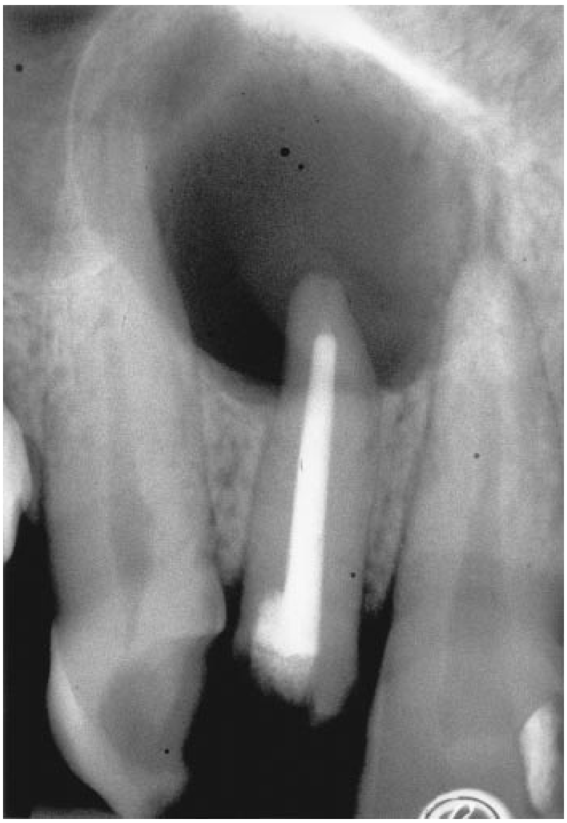

Figure 1 Radiograph showing a large radiolucent area at the apex of the maxillary right lateral incisor. The lesion was diagnosed clinically as a through and through lesion.

Figure 2 Radiograph of the same case as in Fig. 1 at 1 year following apicectomy. A large radiolucent area is clearly visible.

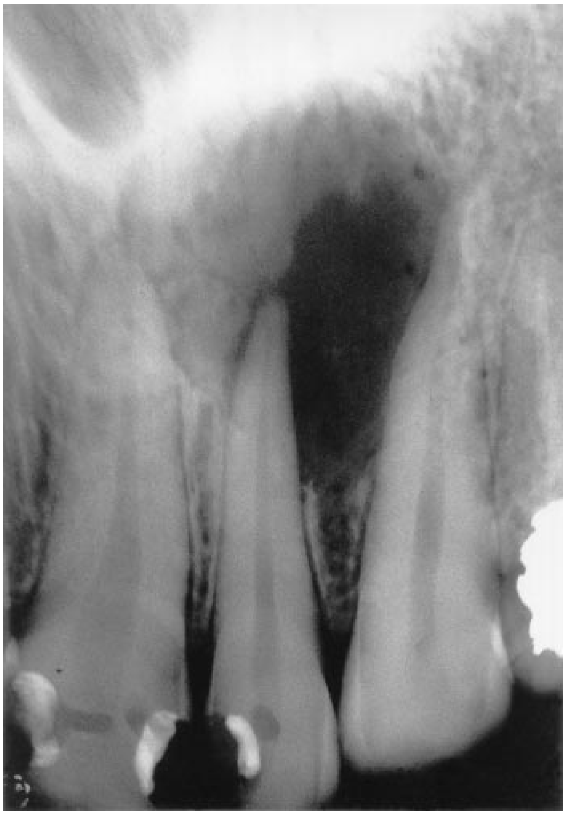

Figure 3 Radiograph showing a large periapical lesion on a maxillary lateral incisor.

Figure 4 Radiograph showing the same lesion as in Fig. 3, 6 months after root canal treatment.

Results

The results are summarized in Table 1. The six- and 12-month evaluation showed the following:

Control group: The six-month control revealed that three teeth were completely healed, five incompletely healed, and two had unsatisfactory healing (cases 1 and 6) (Figs 1, 2). Moreover, tooth 1 showed signs of infection and spontaneous pain during follow-up and was extracted because of a vertical fracture. At 12 months postoperatively the outcome remained the same.

Test group: At 6 months seven sites showed complete healing and two (cases 4 and 8) incomplete healing (Figs 3–6, 7–11). One of the two teeth (case 4) also became infected 1 week postoperatively. In addition, case 6 showed symptoms of tenderness to percussion and swelling 4 weeks postoperatively, and was extracted because of a vertical fracture. For this reason it was excluded from the evaluation of the final outcome. At 12 months no changes were detected compared to the previous screening.

Discussion

Many factors are involved in the healing process of a periapical defect following endodontic surgery. Amongst these, the two layers of the periosteum are very important, as they may act both as a source of osteo-competent cells and as a barrier against the infiltration of epithelial cells into the healing site. However, in large defects such as 'through and through' lesions, especially when a sinus tract is present, the periosteum is often damaged by the infective process. In addition, the reflection of a simple flap further damages periosteum, especially in the 'through and through' lesions where both cortical plates are lost.

The use of a barrier in such lesions is an attempt to improve the regenerative healing process, by excluding undesired cell proliferation (Dahlin *et al.* 1989, Dahlin *et al.* 1990).

In order to achieve a more predictable regeneration, some authors suggest the combined use of barrier membranes and graft materials that may act either as

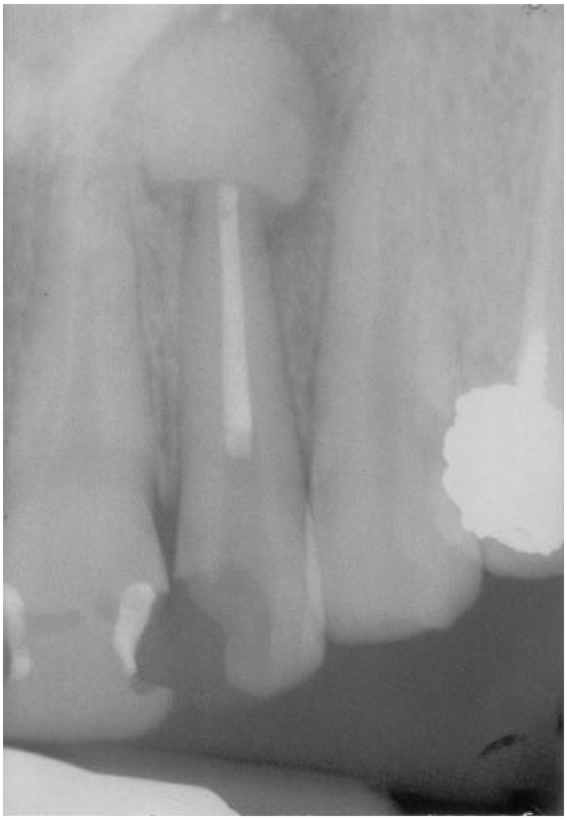

Figure 5 Post-operative radiograph of tooth in Figs 3 and 4 showing calcium sulphate at the apex of the root.

Figure 7 Radiograph showing a large lesion at the apex of a maxillary right lateral incisor. Clinically, it showed suppuration and presence of a fistula.

Figure 6 Follow-up radiograph of tooth in Figs 3–5 at 24 weeks.

Figure 8 Radiograph of tooth in Fig. 7 showing the root canal treatment on the maxillary right central incisor.

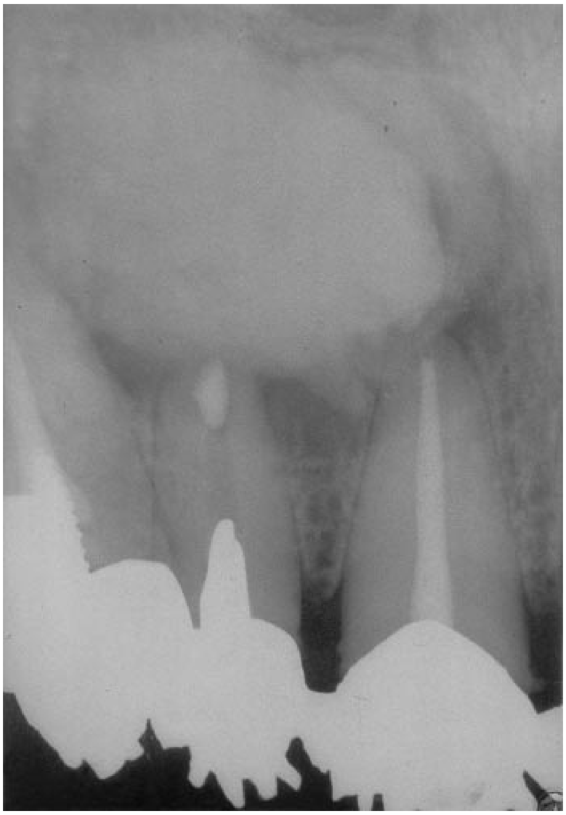

Figure 9 Radiograph of teeth in Figs 7 and 8 taken immediately after apicectomy and root-end filling of the lateral incisor. A grafting procedure of the through and through defect with calcium sulphate has also been performed.

Figure 10 Follow-up radiograph of teeth in Figs 7–9 at 6 months.

space maintainers only or also as 'stimulating factors' (Schallhorn & McClain 1988, Lekovic *et al.* 1990, Anderegg *et al.* 1990).

Calcium sulphate alone or mixed with demineralized freeze-dried bone allograft (Sottosanti 1992a,b) appears to be a promising substance to be used as a filling material under a membrane for regeneration. Recently, the hypothesis that calcium sulphate alone, after complete setting in a dry environment, may act as a barrier has also been tested (Pecora *et al.* 1997). The concept of having a material that could be totally resorbable, safe, maintain space, act as a reservoir of calcium ions for bone mineralization and be inexpensive and able to act as a barrier, is of great benefit.

The results of the present study indicate that the additional use of calcium sulphate graft to conventional surgical therapy of 'through and through' endodontic lesions may contribute to improved clinical outcome. It is the authors' opinion that to follow a correct technique of mixing and application is a key factor for predictable good results with calcium sulphate. In fact, stratification and dry compaction may play a crucial role in achieving a defect fill with no voids and a complete setting of the graft material leading to a good mechanical strength and a reduced resorption rate. Furthermore, the approach proposed by the authors for the 'through and through' lesions was subjectively easier to perform technically than the application of membranes. In fact, with such a technique, there is no longer a need to raise a flap on both sides of the alveolar process.

In the present study, healing was evaluated on the evidence of the radiographic appearance. This has limitations, as the nature of the tissues that have formed within the healed lesions is unknown. An histologic examination is required to collect this type of information and this is being undertaken currently.

Figure 11 Follow-up radiograph of teeth in Figs 7–10 at 12 months.

References

Anderegg CR, Martin SJ, Grey JL, Mellonig J, Gher ME (1990) Clinical evaluation of the use of DFDBA with guided tissue regeneration in the treatment of molar furcation invasions. *Journal of Periodontology* **62**, 264–8.

Blumenthal NM, Singiser RT (1993) The enhancement of Guided Tissue Regeneration by altering root surface topography. *International Journal of Periodontics and Restorative Dentistry* **13**, 361–71.

Brunsvold MA, Mellonig JT (1993) Bone grafts and periodontal regeneration. *Periodontology 2000* **1**, 80–91.

Caffesse R, Smith B, Castelli W, Nasjleti C (1988) New attachment achieved by GTR in beagle dogs. *Journal of Periodontology* **59**, 589–94.

Caton JG, Greenstein G (1993) Factors related to periodontal regeneration. *Periodontology 2000* **1**, 9–15.

Caton J, Nyman S, Zander H (1980) Histometric evaluation of periodontal surgery. II. Connective tissue attachment levels after four regenerative procedures. *Journal of Clinical Periodontology* **7**, 224–31.

Coetzee AS (1980) Regeneration of bone in the presence of calcium sulfate. *Archives of Otolaryngology* **106**, 405–9.

Dahlin C, Linde A, Gottlow J, Nyman S (1989) Healing of bone defects by guided tissue regeneration. *Plastic and Reconstructive Surgery* **81**, 672–6.

Dahlin C, Gottlow J, Linde A, Nyman S (1990) Healing of maxillary and mandibular bone defects using a membrane technique. An experimental study in monkey. *Scandivian Journal of Plastic Reconstructive Hand Surgery* **24**, 13–9.

Diggins I, Clay J, Himel V, Dean J (1994) A combined endodontic retrofill and periodontal GTR technique for the repair of molar endodontic furcation perforation: a case report. *Quintessence International* **25**, 109–14.

Garret S, Bogle G (1993) Periodontal regeneration: A review of flap management. *Periodontology 2000* **1**, 100–108.

Goon V, Lundergan W (1995) Redemption of a perforated furcation with a multidisciplinary treatment approach. A case report. *Journal of Endodontics* **21**, 576–9.

Gottlow J, Nyman S, Karring T, Lindhe J (1984) New attachment formation as the result of controlled tissue regeneration. *Journal of Clinical Periodontology* **11**, 494–503.

Izawa T, Kim S, Suda N, Pecora G, Rubinstein R (1994) Microscopic endodontic surgery. *Quintessence International* **13**, 54–65.

Lekovic V, Kenney EB, Carranza FA Jr, Danilovic V (1990) Treatment of grade II furcation defects using porous HA in conjunction with a PTFE membrane. *Journal of Periodontology* **61**, 575–9.

Listgarten MA, Rosenberg MM (1979) Histological study of repair following new attachment procedures in human periodontal lesions. *Journal of Periodontology* **50**, 333–44.

Lowenguth RA, Bliedent TM (1993) Periodontal regeneration: Root surface demineralization. *Periodontology 2000* **1**, 54–68.

McKee J, Bailey B (1984) Calcium sulfate as a mandibular implant. *Otolaryngology Head and Neck Surgery* **92**, 277–86.

Nyman S, Gottlow J, Karring T, Lindhe J (1982) The regenerative potential of the periodontal ligament; an experimental study in the monkey. *Journal of Clinical Periodontology* **9**, 257–65.

Nyman S, Lindhe J, Karring T, Rylander H (1983) New attachment following surgical treatment of human periodontal disease. *Journal of Clinical Periodontology* **9**, 290–6.

Pecora G, Andreana S (1993) Use of dental operating microscope in endodontic surgery. *Oral Surgery, Oral Medicine and Oral Pathology* **75**, 751–7.

Pecora G, Kim S, Celletti R, Davarpanah M (1995) The guided tissue regeneration principle in endodontic surgery: one year postoperative results of large periapical lesions. *International Endodontic Journal* **28**, 41–6.

Pecora G, Andreana S, Margarone J III, Sottosanti J (1997) Bone regeneration with a calcium sulfate barrier. *Oral Surgery, Oral Medicine and Oral Pathology* **84**, 227–34.

Pecora G, Baek S-H, Rethnam S, Kim S, Phil M (1997) Barrier techniques in endodontic microsurgery. *Dental Clinics of North America* **41**, 585–602.

Rud J, Andreasen JO, Jensen JEM (1972) A follow-up study of

1000 cases treated by endodontic surgery. *International Journal of Oral Surgery* **1**, 215–28.

Schallhorn R, McClain P (1988) Combined osseous composite grafting root conditioning and GTR. *International Journal of Periodontics and Restorative Dentistry* **8**, 8–31.

Sottosanti J (1992a) Calcium sulfate: an aid to periodontal, implant and restorative therapy. *Californian Dental Association* **20**, 45.

Sottosanti J (1992b) Calcium sulfate: a biodegradable and biocompatible barrier for guided tissue regeneration. *Compendium of Continuing Education in Dentistry* **13**, 226–34.