Comparison between a conventional technique and two bone regeneration techniques in periradicular surgery

S. I. Tobón, J. A. Arismendi, M. L. Marín, A. L. Mesa & J. A. Valencia

Departamento de Estudios Básicos Integrados, Facultad de Odontología, Universidad de Antioquia. Medellín, Colombia

Abstract

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Aim The aim was to demonstrate the efficacy of two materials for bone regeneration during periradicular surgery and their effects on the healing of periapical tissues.

Methodology Twenty-eight patients (30 surgical sites) were selected and distributed into three groups: group A, conventional technique; group B, conventional technique plus nonbioabsorbable GoreTex® Augmentation membrane; and group C, conventional technique plus the same membrane placed over a synthetic bioactive resorbable graft of a hydroxylapatite (OsteoGen®) product in the bony defect. Clinical and radiological evaluations were completed immediately prior to surgery, a week later and every 3 months after surgery up to 12 months. Two histological evaluations were performed (at the beginning and at 12 months).

Results The results showed complete clinical and radiographic healing (eight cases) for group C, with histologic evidence of trabecular bone in all cases. For group B, six out of nine cases showed complete radiographic healing, incomplete in one case and uncertain in two cases, with histologic evidence of trabecular bone in five out of eight cases, scar tissue in one case and granuloma in two cases. For group A, there was complete radiographic healing in four out of nine cases, incomplete in four and unsuccessful in one case, with evidence of granuloma in four out of eight, scar tissue in two cases and trabecular bone in two cases.

Conclusions It was concluded that the conventional technique was less predictable in its healing response during the 12 months of this study. The use of bone regeneration materials, such as nonbioabsorbable membranes and resorbable hydroxylapatite improved the predictability of clinical, radiographic and histological healing.

Keywords: guided bone regeneration, membranes, periradicular surgery, synthetic bone substitutes.

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Introduction

Most periapical radiolucent lesions heal uneventfully after endodontic treatment. However, some cases may require periradicular surgery in order to remove pathologic tissue from the periapical region and simultaneously eliminate any source of irritation that could not be removed by orthograde root canal treatment. With an adequate technique, surgery can address these issues, although it may be insufficient in some situations (Perlmutter *et al.* 1988).

Regeneration of periapical bone defects constitutes a significant problem in periradicular surgery, since the proliferation of gingival connective tissue or the migration of the oral epithelium into such defects can occur and prevent the formation of normal trabecular bone (Dahlin *et al.* 1988).

Several studies in humans and animals have evaluated the concept of guided tissue regeneration (GTR). This has led to the development of synthetic bone substitutes, bone grafts and membranes or barriers that allow the

Correspondence: Sergio Iván Tobón Arroyave, Calle 67 N°53–108, PO Box 1226, Medellín, Colombia (fax: 57 4 2631230; e-mail: gflorez@epm.net.co).

cellular re-growth of periodontal defects caused by pathosis or surgical trauma (Wang & MacNeil 1998).

The principle of GTR used in periodontics has been applied in periradicular surgery with success by some clinicians who have reported an excellent recovery in cases that originally had a poor prognosis. This has helped to improve the predictability of periapical surgical procedures (Pecora *et al.* 1995, Rankow & Krasner 1996, Uchin 1996, Pecora *et al.* 1997). With these new techniques, the migration of cells of the gingival connective tissue or oral epithelium is prevented, allowing the cells of the periodontal ligament and trabecular bone to regenerate the lost tissue (Dahlin *et al.* 1988, Nyman 1991, Rankow & Krasner 1996, Uchin 1996, Pecora *et al.* 1997, Laurell & Gottlow 1998, Aichelman-Reidy & Yukna 1998, Wang & MacNeil 1998).

The indications suggested for GTR in endodontic surgery are: through-and-through lesions that involve the integrity of both the buccal (labial) and palatal (lingual) alveolar cortical plates; chronic periapical lesions and combined endodontic–periodontic involvement, such as communication of periodontal pockets with periapical lesions, compromised bifurcation or trifurcation crests, and root perforation with alveolar crest bone loss (Pecora *et al.* 1997).

The aim of this project was to investigate the efficacy of two bone regeneration techniques in periradicular surgery and their effect on the healing of periapical tissues.

Materials and methods

Twenty-eight patients were selected (10 men and 18 women), ages 14 through 74 (average 39.2 years), for a total of 30 surgical sites. The requirements for surgery were: previous root canal treatment and retreatment, post and crown in the tooth, and failed previous surgery. Sixteen sites were in anterior teeth and 14 in premolar teeth; 23 were maxillary teeth and seven mandibular. Two patients had two surgical sites. The informed consent of all human subjects who participated in this study was obtained after the nature of the procedure and possible discomforts and risks were fully explained. Furthermore, the protocol was evaluated and approved by the Research Development Committee of the University of Antioquia for ethical considerations (CODI-Code 280–97).

Three groups were randomly established, each with 10 surgical sites. Surgery was completed by one operator (SIT). Group A (control group) had periradicular surgery with a conventional technique (Fig. 1). In group B

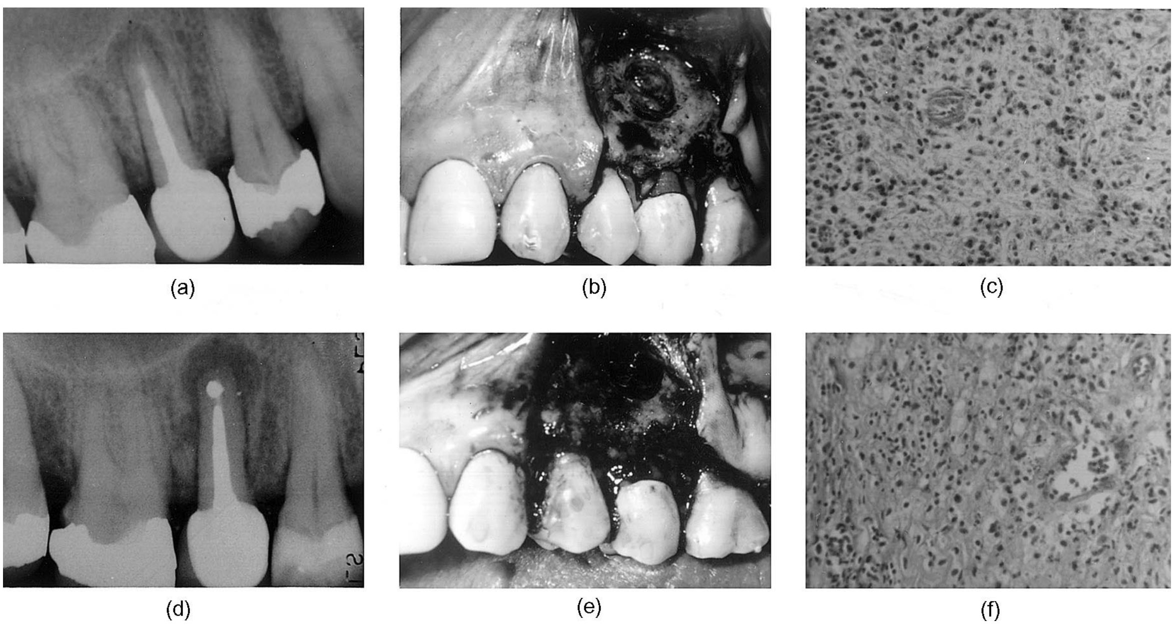

Figure 1 Conventional technique (group A). (a) Pre-operative radiograph of periapical lesion. (b) Small bone defect on maxillary left second premolar following periradicular surgery root-end filled with amalgam. (c) Histological section demonstrating granulomatous tissue obtained from original lesion. (d) The same case 12 months post-operative showing a persistent pariapical radiolucency. (e) Unsatisfactory healing observed at re-entry surgery. (f) Histological healing showing granulomatous tissue at 12 months.

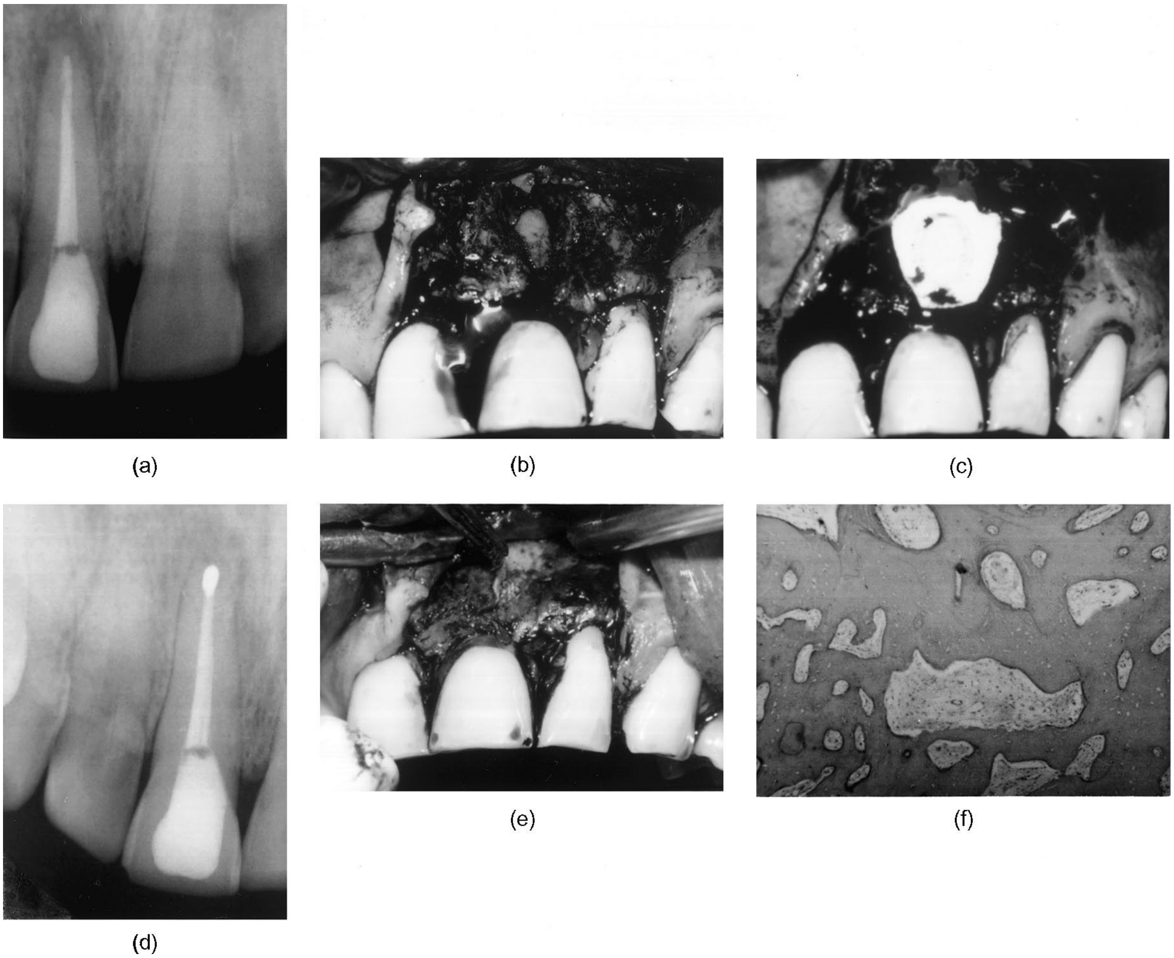

Figure 2 A barrier technique case (group B). (a) Maxillary central incisor with a periapical lesion. (b) Large bone defect showing an apical pathosis with communication to the alveolar crest. (c) Placement of membrane (e-PTFE) over the entire defect. (d) Complete healing radiographically at one year. (e) Membrane removal at re-entry surgery. A bone-like hard tissue covers the defect (f) Histological healing showing formation of normal trabecular bone.

(experimental group 1), the patients had periradicular surgery with the addition of a nonbioabsorbable membrane of expanded polytetrafluoroethylene (e-PTFE) GoreTex® Augmentation Gt4 submerged configuration (W.L. Gore & Associates, Flagstaff, AZ, USA) (Fig. 2). In group C (experimental group 2), patients had periradicular surgery with a synthetic bioactive resorbable graft known as resorbable hydroxylapatite OsteoGen® (Impladent Ltd, Holliswood, NY, USA) placed in the bony defect followed by the e-PTFE (GoreTex®) over the entire defect (Fig. 3).

The treatment protocol in all three groups was established in accordance with the following general scheme: (a) medical-dental history, clinical evaluation and initial radiograph; (b) surgical procedure, including mucoperiosteal flap reflection, osteotomy, periradicular curettage-enucleation, root-end resection with cylindrical surgical carbide finishing bur at high speed, cavity preparation with an inverted cone bur and root-end filling with zinc free silver alloy amalgam Nu-alloy® (New Stetic, Medellín, Colombia), using a Messing® syringe (Union Broach, Moyco, Ind., Emigsville, PA, USA).

In groups B and C, the membrane placement was extended 2–3 mm beyond the defect margins (Figs 2c and 3c), and in group C, the hydroxylapatite was placed until it was level with the peripheral margins of the bone defect (Fig. 3b). The sutures were removed between 7 and 10 days after the operation and then clinical and radiographic controls were performed every 3 months up to 12 months. Another surgical procedure was

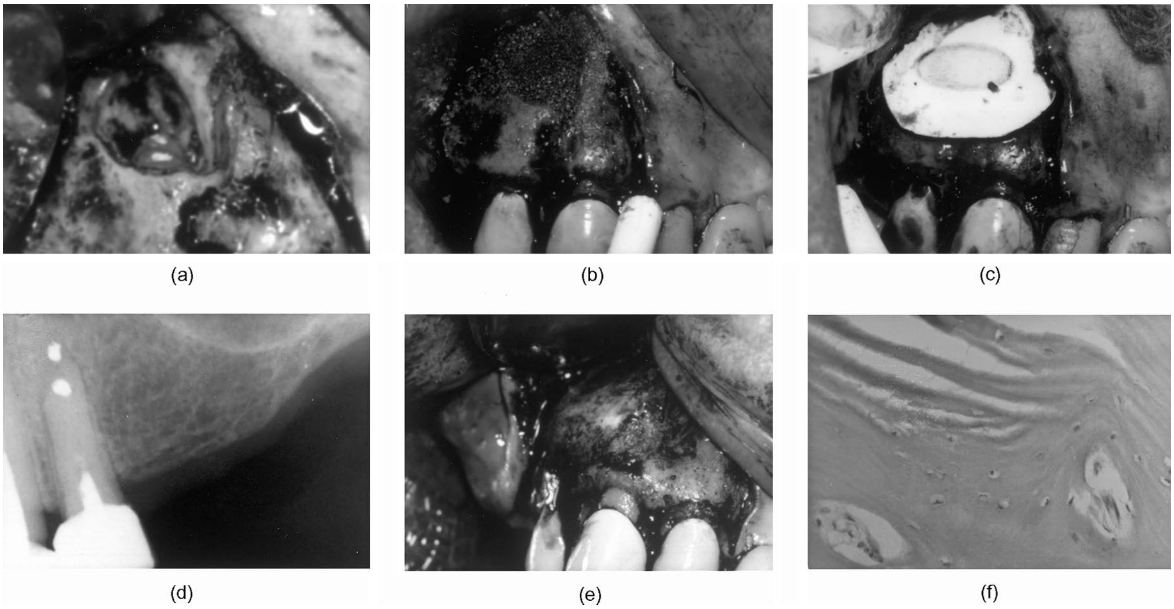

Figure 3 A barrier technique plus synthetic filling material (group C). (a) Bone defect after debridement and root-end filling. (b) Bioabsorbable hydroxylapatite placement. (c) Membrane placement (e-PTFE) over the entire defect. (d) Complete healing 12 months later. (e) Apical healing with bone fill. (f) Histological healing showing formation of normal trabecular bone.

carried out in order to remove the membrane in the experimental groups and to take samples of tissue for histological evaluation from the periapical area of all patients with a 3i® surgical bur (Implant Innovations, Palm Beach Gardens, FL, USA) of 2 mm in diameter and 2 mm in depth, at low-speed with water coolant.

The diagnostic and control radiographs were taken with the Rinn® (XCP® Instruments, Elgin, IL, USA) parallel technique and radiographic analysis compared the initial size of the lesion on the pre-operative film with the images on the follow up films. A Kodak Achromatic® (Eastman Kodak Co., Rochester, NY, USA) 5× magnifying lens was used to measure the lesion area in mm^2 and the percentage reduction on the final radiograph. These measurements and the qualitative changes generated in the apical rarefaction were used to assign each case to the categories of radiographic healing described by Rud *et al.* (1972).

The histological specimens were placed in 10% buffered formalin and then processed and stained with haematoxylin-eosin. The sections were observed with a light microscope Zeiss Axiolab® (Carl Zeiss, Oberkochen, Germany) at 10× and 40× magnification.

Statistical analysis for the variable 'size of the radiographic lesion' was based on the Kruskal–Wallis test, with the purpose of establishing if there were any significant differences amongst the groups with a level of significance of 5% ($P \leq 0.05$). The initial and final evaluation within each group was performed using the Student's *t*-test for paired samples. The data for 'radiographic healing' and 'histologic healing' were analysed based on the percentage distributions in order to produce a descriptive analysis.

Results

Of the 28 patients registered for the study, three had to be removed from the study for different reasons: one patient (group C) needed further surgery 2 months after the initial operation for a subperiosteal abscess in the lingual aspect originating from a neighbouring tooth. Another patient, with two surgical sites (groups A and C) did not return for reviews. One patient from group B was removed because of a vertical root fracture. At the end of the study, 25 patients with 26 surgical sites were examined. Of these, one patient from group A refused further surgery for the histological sample. One patient from group B refused to allow a tissue sample to be taken during the second surgical procedure for membrane removal.

Table 1 shows the results of the radiographic evaluation of the size of the periapical lesions, comparing initial and final measurements. In group A, there was a tendency towards reduction of the size of the lesion, with

Table 1 Radiographic size of periapical lesion in mm^2 by group comparing initial and final measurements

Conventional technique			Barrier technique			Barrier technique and hydroxylapatite		
Initial assessment	Final assessment	Percentage reduction	Initial assessment	Final assessment	Percentage reduction	Initial assessment	Final assessment	Percentage reduction
28.08	6.4	77.2	135	12.92	90.41	25.92	0	100
32.48	0.08	99.8	30.72	0	100	506	0	100
13.6	0	100	18.4	6	67.4	25	0	100
21.84	25	−14.5	0.04	0.04	0	31.2	0	100
32.4	6	81.5	28	0	100	19.2	0	100
195	0	100	143	0	100	21.2	0	100
33.48	6.4	80.9	0	0	100	16	0	100
3.2	0	100	29	0	100	42.92	0	100
13.68	0	100	53.28	0	100			

only one case in which the periapical radiolucent image increased in size (Fig. 1d). Group B had a tendency towards reduction of the size of the lesion in all treated cases, except in one case where the lesion remained the same size. In group C, complete resolution of the periapical lesions was observed in all cases.

The student's *t*-test for the radiographic analysis of healing by individual groups, showed that a significant difference existed between the initial and final values for groups B ($P = 0.02$) and C ($P = 0.0002$) in relation to bone healing. There was no significant difference between the initial and final values for group A ($P = 0.1$).

The results of the statistical analysis of the binary comparison with groups for the radiographic evaluation, showed that there was no significant difference between the size of the lesions in the initial radiographic evaluation amongst the groups, whilst the results of the Kruskal–Wallis test for the final data of the radiographic evaluation showed that there was a significant difference when comparing groups A and C ($P = 0.016$), but no statistically significant difference between groups A and B ($P = 0.285$) or between B and C ($P = 0.082$).

For radiographic healing by groups, a year after surgery (Table 2), in group A, there were four out of nine cases with complete healing; in group B, there were six out nine cases with complete healing; and in group C, all eight cases (100%) had complete healing.

Table 3 summarizes the histological findings of biopsies taken during the second surgical procedure. The cases diagnosed as apical granuloma exhibited identical characteristics to the ones observed for the initial samples (Fig. 1c,f). The cases with scar tissue were characterized by a vascularized dense fibrous connective tissue. The cases registered as bone showed new formation of normal trabecular bone surrounded by osteoblastic activity (Figs 2d,f and 3d,f). None of the biopsies showed any remains of the membrane or crystals of the hydroxylapatite material.

The re-entry procedures showed evidence of filling of the bone defect with a dense hard tissue in those cases that showed that the surgery had been successful at the final radiographic exam (Fig. 3e), except for a case (group A) in which granulomatous tissue was found. In cases with uncertain or unsatisfactory healing radiographically, there was granulomatous tissue (Fig. 1e). In cases with incomplete healing, fibrous tissue was strongly attached to the radicular surface in three cases, and granulomatous tissue in the two remaining cases. The membranes appeared to have been mechanically integrated to the tissue, offering resistance to removal.

Table 2 Radiographic healing one year after surgery by experimental group

	Conventional technique		Barrier technique		Barrier technique and hydroxylapatite	
Radiographic healing	*N*	%	*N*	%	*N*	%
Unsatisfactory	1	11.11	0	0	0	0
Uncertain	0	0	2	22.22	0	0
Incomplete	4	44.44	1	11.11	0	0
Complete	4	44.44	6	66.66	8	100
Total	9	100	9	100	8	100

Note: Data based on 25 patients with 26 surgical sites.

Table 3 Histological healing one year after surgery by experimental group

Healing	Conventional technique[a]		Barrier technique[b]		Barrier technique and hydroxylapatite	
	N	%	*N*	%	*N*	%
Granuloma	4	50	2	25	0	0
Scar tissue	2	25	1	12.5	0	0
Trabecular bone	2	25	5	62.5	8	100
Total	8	100	8	100	8	100

Note: Data based on 23 patients with 24 surgical sites.
[a]One group A patient without re-entry surgery.
[b]One group B patient without histolgical sample.

Discussion

A number of studies have evaluated the long-term results after periradicular surgery, using diverse clinical and radiographic parameters (Harty *et al.* 1970, Rud *et al.* 1972, Mikkonenn *et al.* 1983, Friedman *et al.* 1990, Pecora *et al.* 1995). In some studies, success rates under 50% were reported (Friedman *et al.* 1990), whilst others had success rates of 90% (Harty *et al.* 1970) or even 100% (Pecora *et al.* 1995). This wide variation in the results is a reflection of the multiplicity of surgical concepts, materials and methods used; differences in the criteria over which the healing parameters are based on, the observation periods, age groups studied, differences between patients, teeth and selection criteria. Of the three surgical variants in the current study, some difference in the results after a year of evaluation was observed. The results reported in the classic radiographic study of Rud *et al.* (1972) present 35.83% with unsatisfactory healing, 23.33% uncertain healing, 23.33% incomplete healing and 17.5% complete healing with a conventional technique in 120 cases. The results in this study showed a better radiographic response, particularly in group C, which may have been a result of the use of OsteoGen® and the nonbioabsorbable membrane GoreTex®.

The statistical analysis established a significant difference between the final values of the sizes of the radiographic periapical lesions in groups A and C, from which it can be deduced that C is better than A.

The size of the lesion may be a critical factor because the distance between hard and soft tissues could determine the type of tissue that will grow during healing. If fibrous tissue establishes itself first, it will probably act as a barrier to prevent bone formation (Pecora *et al.* 1995). Tay *et al.* (1978), established that when the pathological area increases in size the rate of success of periradicular surgery decreases, but lesions of more than 12 mm showed a tendency to have complete repair similar to small lesions. In the current study, when regeneration techniques were used, with or without synthetic filling material, the lesions of larger size had healed completely in 12 months. When the conventional technique was used, there were persistent small radiolucent areas in those larger lesions. Pecora *et al.* (1995) evaluated the healing of periapical lesions of more than 10 mm, and showed clinical and radiographic evidence of complete bone regeneration, when the membrane technique was used as a barrier. In the current study, the histological analysis demonstrated that when Gore-Tex® membranes were used, there was bone regeneration in most of the cases in groups B and C, whilst in group A, bone regeneration was observed in only some cases. However, it could be that group A require more time for healing to be completed.

The results obtained in the histological evaluations were similar to the studies reported by Dahlin *et al.* (1988) and Nyman (1991) in experimental studies in animals. The better results obtained in group C are possibly related to the simultaneous use of a synthetic filling material (bioabsorbable hydroxylapatite), which has been recommended as necessary to keep the existing space in the bone defects under the barrier (Rankow & Krasner 1996), achieving better results than with the membrane alone. Thus, the simultaneous use of regeneration techniques and filling materials, allows a more predictable healing response by the action of a double mechanism: firstly, the membrane allows the re-population of the defect with regenerative cells derived from the periodontal ligament and the endosteum; and secondly, the filling material acts as reservoir and matrix for the deposition of new bone.

Conclusions

The results when considered within the limitations of this study indicate that:

1 There was a good clinical and radiographic response at 12 months with the conventional technique, although histological results obtained at the time of the re-entry surgery indicated a less favourable evolution.

2 The use of a nonbioabsorbable membrane alone as a barrier resulted in bone regeneration in most of the cases according to clinical, radiographic and histological evaluation.

3 The simultaneous use of a nonbioabsorbable membrane and a synthetic bioactive resorbable hydroxylapatite graft produced complete regeneration of bone as observed clinically, radiographically and histologically.

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