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ORIGINAL ARTICLE

The use of Enamel Matrix Derivative (Emd) for Treatment of Combined Apicomarginal Lesions in Apical Surgery: A Retrospective Analysis

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ABSTRACT

Objective: The outcome of apical surgery using modern techniques is favourable. However, the presence of a combined apicomarginal defect may negatively affect the postsurgical healing. The objective of this retrospective analysis was to assess the healing of teeth with apicomarginal defects treated with apical surgery and enamel matrix derivative (EMD).

Methods: This retrospective study evaluated the application of EMD in apical surgery of 17 teeth with apicomarginal defects. Cases were followed for at least 1 year, and healing was classified based on established clinical and radiographic criteria.

Results: The patient sample included nine females and eight males with a mean age of 50±18.2 years. Maxillary incisors (six lateral and four central) were the most frequently treated teeth. The majority of apicomarginal defects was located on the facial aspect of the root (70.6%) and belonged to defect class I (76.5%). Follow-up periods ranged from 1 to 5 years. Healing was successful in 14 teeth (82.4%).

Conclusion: The application of EMD resulted in a similar outcome as in previously published clinical studies related to regenerative techniques for the treatment of apicomarginal defects in conjunction with apical surgery.

Keywords: Apical surgery, enamel matrix derivative, endo-perio lesion

HIGHLIGHTS

- In conjunction with apical surgery, apicomarginal defects were treated using enamel-matrix derivatives, but no bone fillers or membranes were applied.
- The outcome in the present study was similar to data from previous clinical studies that utilized other regenerative techniques for treatment of apicomarginal defects in combination with apical surgery.
- Published clinical and nonexperimental data with regards to the therapeutic approach of apicomarginal defects remain limited.

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INTRODUCTION

Apical surgery using microsurgical principles is a well-established treatment option in endodontics. Modern techniques of apical surgery have shown high success rates, and 1-year results are reasonably suggestive of the long-term prognosis (1). However, periapical healing may be compromised in situations, in which the apical lesion has extended along the root surface to the marginal periodontium. Such a combined endo-perio lesion, or apicomarginal defect, carries the risk of epithelial downgrowth along the denuded root surface following apical surgery (2). The apical extension of the junctional epithelium may result in the establishment or recurrence of the communication between the marginal periodontium and apical area, thus jeopardizing the healing outcome but also carrying the risk of gingival recession with aesthetic concern (3).

Several papers have proposed classifications for the location and extent of periradicular lesions in conjunction with apical surgery (4–6). Such classifications are helpful to categorise lesions, treatment selection, and reported outcome. Following the establishment of (guided) tissue regeneration techniques in periodontology and implant dentistry, there has been a growing interest in using this treatment option also in apical surgery (3). Regenerative techniques include the use of barrier membranes, bone replacement/filler materials, growth factors, or combinations thereof.

In the early 1990s, a Swedish team of researchers demonstrated the biologic capability of enamel matrix proteins (EMP) for periodontal regeneration. The major component of EMP is amelogenin that constitutes about 90% of the matrix. EMP were found to be involved in the development and prere-

generation of root cementum (7). In the very first animal experiment about EMP, its positive effect on periodontal regeneration was demonstrated in a buccal dehiscence model in monkeys (8). The purified fraction of EMP, derived from the enamel layer of developing porcine teeth, was subsequently given the working name "enamel matrix derivative" (EMD) and was marketed as Emdogain® (Straumann, Basel, Switzerland) (9).

Clinical applications of EMD in dentistry have been reported in periodontology, dental traumatology, and endodontics. Indications for EMD in periodontology include angular intrabony defects, class II furcation defects, and recession defects (9, 10). In dental traumatology, EMD has been used adjunctively for replantation of avulsed teeth, but without convincing results (11, 12). The treatment of teeth with posttraumatic external replacement resorption using EMD in conjunction with intentional replantation has shown a recurrence rate of ankylosis in 53% (13). In endodontics, case reports have documented the application of EMD for treatment of buccal or palatal radicular grooves, in conjunction with tooth autotransplantation, and for the management of large endodontic lesions around dental implants (14–17).

The objective of this retrospective analysis was to assess the healing profile of teeth with apicomarginal defects treated with apical surgery and EMD.

MATERIALS AND METHODS

Our database of teeth treated with apical surgery was screened for the following criteria:

- apicomarginal defect,
- adjunctive use of EMD during apical surgery,
- minimum follow-up of 1 year.

All cases were treated by the same surgeon using a surgical microscope (Möller Denta 300; Haag-Streit International, Köniz, Switzerland). Full mucoperiosteal flaps were raised. Osteotomy and 3-mm root-end resection were done with rotary instruments under irrigation with saline. Root-ends were prepared with ultrasonic microtips (Endo success apical kit; Satelec Acteon, Merignac, France) (for root-end filling with mineral trioxide aggregate [MTA, ProRoot®; Dentsply Tulsa Dental, Tulsa, USA] or bioceramic root repair material [BC RRM, Total Fill®; Brasseler BUSA, Savannah, USA]) or alternatively with round diamond burs (for root-end sealing with composite, Retroplast; Retroplast trading, Rorvig, Denmark). The apicomarginal defects were thoroughly cleaned with hand instruments. Denuded root surfaces were conditioned with 24% EDTA (PrefGel®, Straumann, Basel, Switzerland) for 1 minute and subsequently rinsed with saline. Immediately before flap repositioning, the EMD (Emdogain®, Straumann, Basel, Switzerland) was applied to the apicomarginal defect in order to cover the exposed root surface. Wound margins were reapproximated using single interrupted sutures (Seralon®; Serag-Wiessner GmbH, Naila, Germany). Patients were prescribed nonsteroidal analgesics and chlorhexidine mouthwash. Sutures were removed 5–7 days postoperatively.

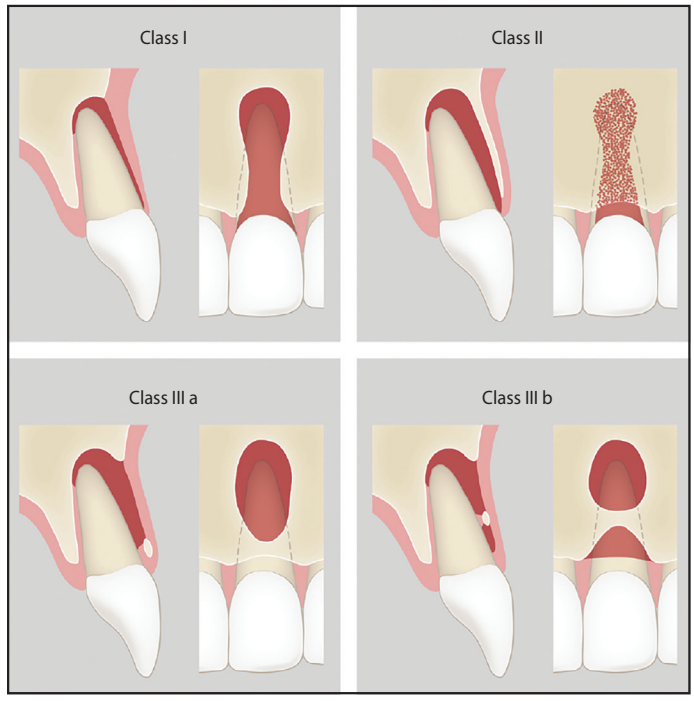

Figure 1. Schematic illustration of classification of apicomarginal defects

Seventeen patients fulfilled the inclusion criteria, and their charts and radiographs were retrospectively evaluated. Healing was determined clinically (absence or presence of signs and/or symptoms) and radiographically, i.e., complete, incomplete, uncertain, or unsatisfactory resolution of radiolucency according to the criteria defined by Molven et al. (18):

- Successful: Absence of clinical signs/symptoms and complete/incomplete radiographic healing,
- Doubtful: Absence of clinical signs/symptoms and uncertain radiographic healing,
- Failed: Presence of clinical signs/symptoms or unsatisfactory radiographic healing.

Apicomarginal defects were categorized into three classes (Fig. 1) by visualization after flap reflection:

- Class I: Complete denudation of facial root surface,
- Class II: Complete apicomarginal defect with thin buccal bone plate,
- Class III: Incomplete denudation of facial root surface with (a) marginal bony bridge of ≤2 mm width, or (b) paramarginal bony bridge of ≤2 mm width.

Periodontal probing was evaluated preoperatively and at the follow-ups using a periodontal probe (Colorvue Tip, Hu-Friedy, Leimen, Germany). Pocket depths and levels of gingival margin were assessed to the nearest 0.5 mm at four aspects: mesiobuccal, midbuccal, distobuccal, and oral (midpalatal/midlingual). The probing force amounted to approximately 0.2–0.3 N.

Figure 2. Clinical preoperative situation (57-year old male): severely discolored left maxillary lateral incisor presenting a sinus tract at the mucogingival junction. Pocket probing depths were ≤2.5 mm

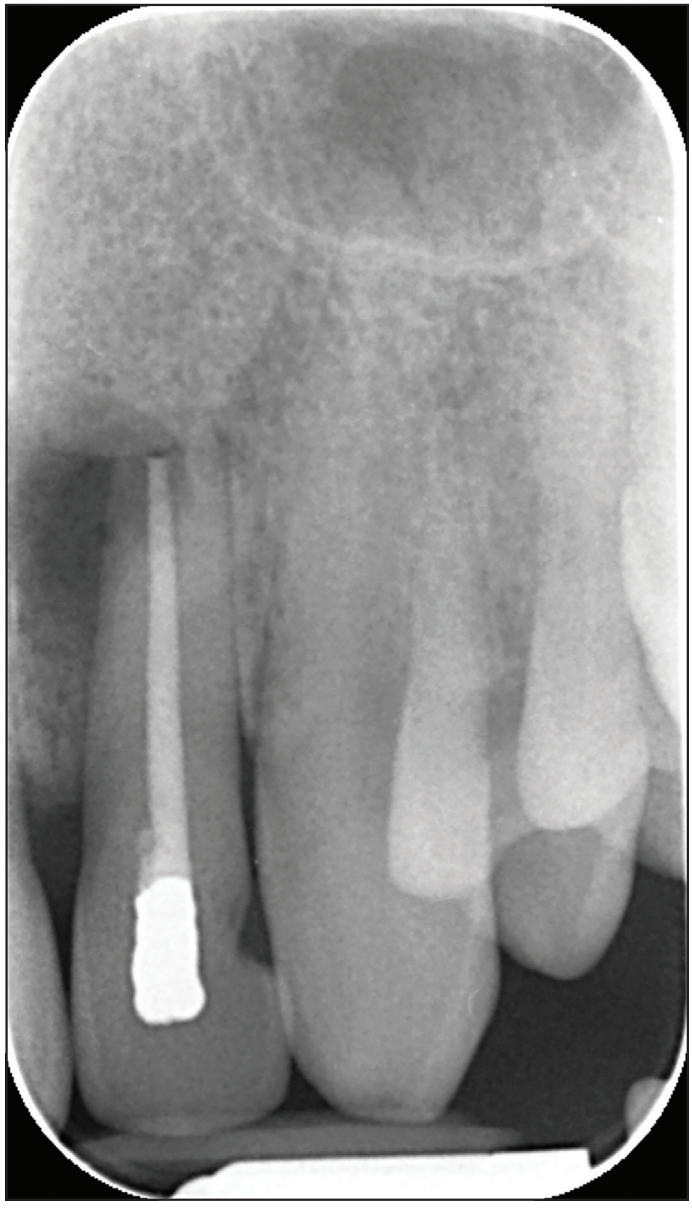

Figure 3. The periapical radiograph depicts a marked radiolucency located at the mesial aspect of the root

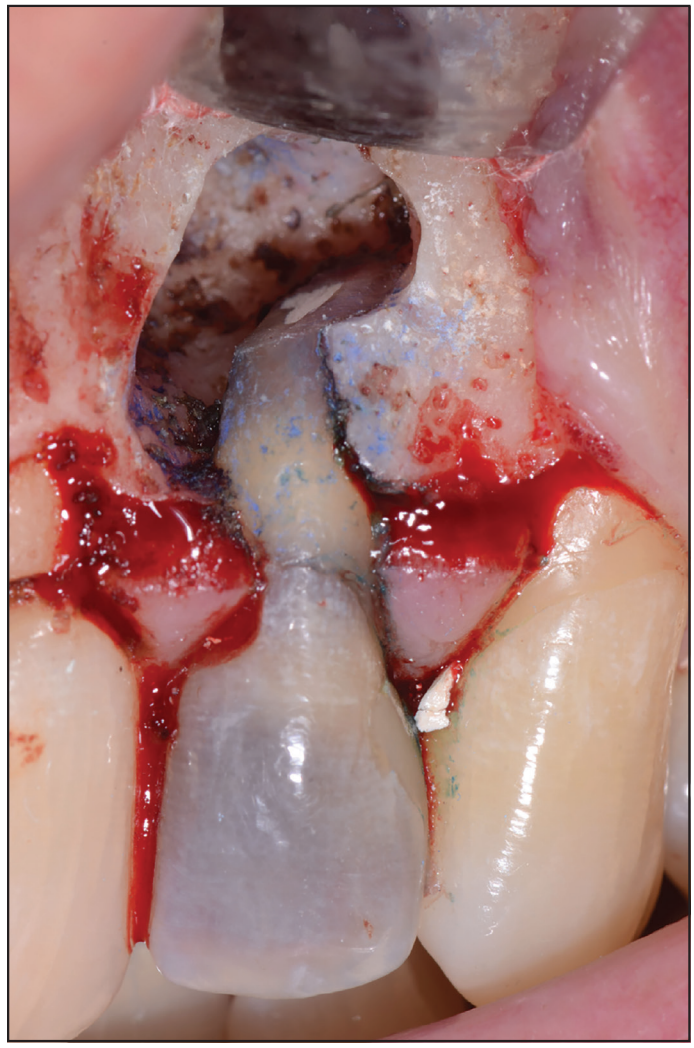

Figure 4. Intraoperative situation showing a Class I apico-marginal defect on the facial root aspect. The root has already been resected and root-end filled. Note the papilla-base incision technique

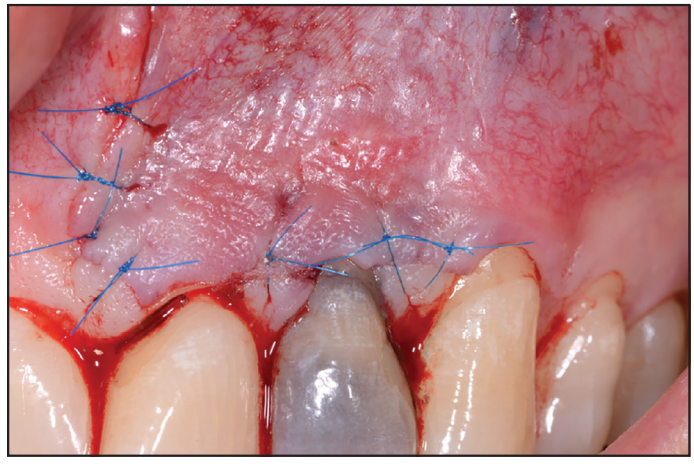

Figure 5. Re-approximation of wound margins using single interrupted sutures (6-0 and 7-0)

RESULTS

Details of patients' sex and age, treated teeth, defect types, as well as clinical and radiographic healing outcomes are presented in Table 1. The study samples included nine females

TABLE 1. Details of the treated cases (n=16)

Case #	Gender	Age	Tooth/ root	Defect type/site	REF	Follow-up	Radio-graphic healing	Clinical findings	Outcome
1	Male	57	22	I/facial	BC RRM	1 y	Complete	-	Success
2	Male	38	22	IIIb/facial	BC RRM	1 y	Incomplete	-	Success
3	Female	67	21	I/facial-distal	BC RRM	1 y	Uncertain	Gingival recession	Doubtful
4	Female	63	26 mb	I/distal	BC RRM	1 y	Complete	-	Success
5	Male	61	26 mb	I/facial	MTA	1 y	Complete	-	Success
6	Female	49	12	I/facial	BC RRM	1 y	Incomplete	-	Success
7	Female	67	12	I/facial	MTA	1 y	Complete	-	Success
8	Female	72	13	I/facial	MTA	2 y	Complete	-	Success
9	Male	51	21	IIIa/facial	MTA	1 y	Complete	-	Success
10	Female	22	22	I/facial	MTA	1 y 2 m	Complete	-	Success
11	Male	24	16 mb	I/facial	MTA	3 y	Uncertain	Soft tissue recession and fenestration	Failure
12	Female	67	21	I/facial	MTA	1 y	Complete	Fistula	Failure
13	Male	55	26 mb	IIIb/facial-distal	MTA	1 y 2 m	Complete	-	Success
14	Female	36	22	I/facial	Composite	1 y 6 m	Complete	-	Success
15	Female	51	44	I/facial	Composite	5 y	Complete	-	Success
16	Male	61	27 mb	II/facial-mesial	Composite	5 y	Complete	-	Success
17	Male	9	21	I/facial	MTA	5 y	Complete	-	Success

mb: Mesiobuccal; BC RRM: Bioceramic root repair material; MTA: Mineral trioxide aggregate; REF: Root-end filling

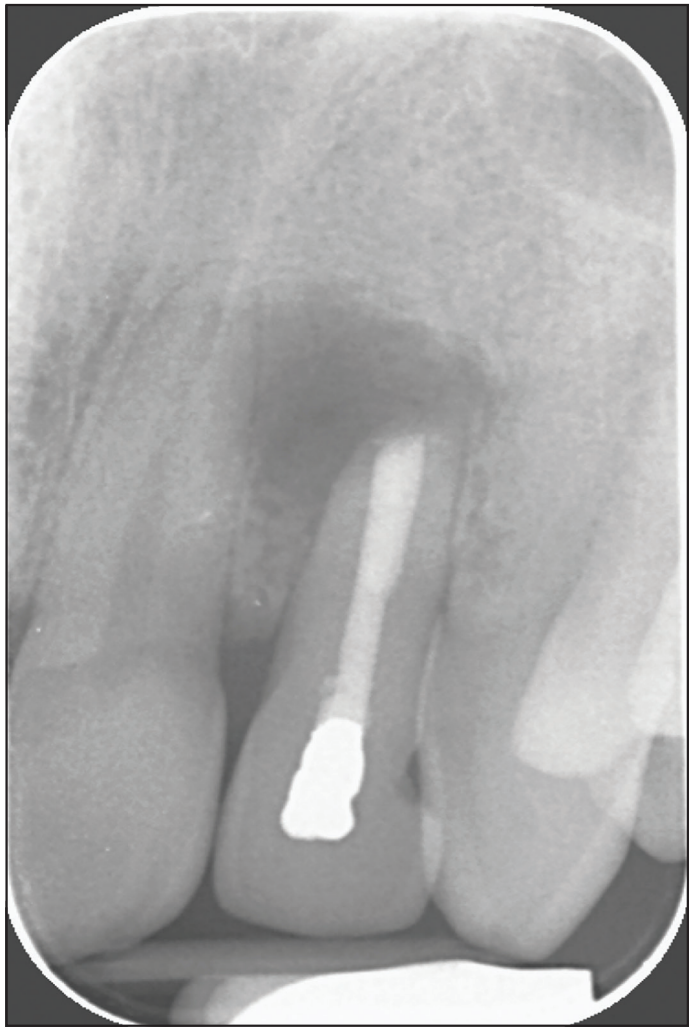

Figure 6. Postoperative periapical radiograph

Figure 7. Clinical situation one year after surgery. Gingival recession amounted to 1.5 mm on the facial root aspect but pocket probing depth were ≤2 mm

and eight males with a mean age of 50.0±18.2 years (median age, 55 years; age range, 9–72 years). Maxillary incisors (six lateral and four central incisors) were the most frequently treated teeth. The majority of apicomarginal defects was located on the facial aspect of the root (n=12, 70.6%) and belonged to defect class I (n=13, 76.5%) (Fig. 2–8). Nine of the evaluated cases had a follow-up period of 1 year. For the other cases, follow-up periods ranged from 14 months to 5 years. Healing was successful in 14 patients (82.4%).

DISCUSSION

While there is abundant evidence on the use of EMD in periodontal surgery, this is the first clinical report that describes the use of EMD in apical surgery. Previous clinical studies evaluated other regenerative techniques for the treatment of

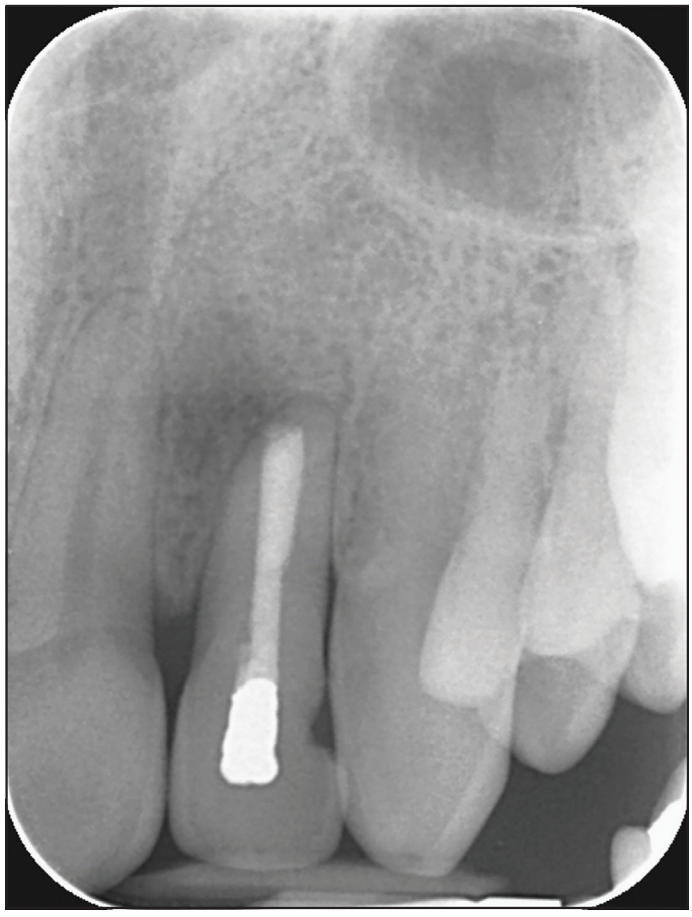

Figure 8. The 1-year periapical radiograph exhibits full resolution of the former radiolucency with establishment of a normally sized periodontal ligament space

apicomarginal defects in apical surgery (19–23, Table 2). The reported rates of successful healing ranged from 74% to 89%. Of these studies, only one study included a control group (23). Interestingly, those authors described no statistically significant difference with regard to the success rates of test (87%) versus control (80%) teeth. Dhiman et al. (23) attributed the favourable results of the control group to the utilization of modern microsurgical techniques and biomaterials. In older studies using the "traditional technique" of apical surgery, the success rates in teeth with completely denuded buccal root surfaces and without regenerative treatment were 27% (24), 30% (2), and 82% (25), respectively.

The management of apicomarginal defects should consider the defect configuration as well as the characteristics of the denuded root surface. With regards to the defect configuration, the apicomarginal communication is often limited to the facial root aspect. However, it may extend to the proximal (mesial and/or distal) root surfaces. The latter configuration is problematic, particularly in multiroot teeth, given that the apicomarginal defect may include the bifurcation area. With respect to the surface characteristics of the exposed root, absence of bone does not necessarily mean complete absence of periodontal tissue on the root surface. If preoperative probing is within normal range, connective tissue attachment may still be present. Following flap elevation, such periodontal tissue remnants on an apparently denuded root surface can be visualized by intraoperative staining (methylene blue). In such a situation, the root surface should not be curetted in order to preserve periodontal tissue remnants.

Most of cases in this report were maxillary incisors (n=10) or mesiobuccal roots of maxillary molars (n=5). The facial bone over these roots is usually very thin (26, 27), and therefore, bone dehiscences may facilitate the development of an apicomarginal lesion on the facial root aspect. In fact, 12 out of 16 apicomarginal defects were located on the facial aspect.

While the traditional GTR technique implies the application of a barrier membrane to exclude an undesired propagation of soft tissue into the defect, the use of growth factors for healing of bone defects has rather a biologic than a mechanical rationale. So far, only one experimental study on dogs has evaluated the effects of EMD in apical surgery (28). The authors reported that the healing of the former periapical defect was better when EMD was applied, and new cementum was dom-

TABLE 2. Clinical studies on regenerative techniques in apical surgery for treatment of combined apicomarginal lesions

Author(s) year	Study type	Regenerative technique	N initial	Follow-up follow-up	Success rate	Statistics
Dietrich et al. 2003 (19)	Prospective cohort study	ABBM+collagen membrane	25	23	1 year	83%	NA
Marin-Botero et al. 2006 (20)	Randomized clinical trial	Periosteal graft	15	15	1 year	87%	No significant difference
		Polyglycolic membrane	15	15	87%		
Kim et al. 2008 (21)	Retrospective cohort study	Calciumsulfate+ collagen membrane	NA	19	1–5 years	74%	NA
Goyal et al. 2011 (22)	Randomized clinical trial	Collagen membrane	10	10	1 year	80%	No significant difference
		PRP	10	6		83%	
		PRP+collagen sponge	10	9		89%	
Dhiman et al. 2015 (23)	Randomized controlled trial	PRF	15	15	1 year	87%	No significant difference
		Control	15	15		80%	
von Arx & Bosshardt (present study)	Retrospective cohort study	EMD	NA	17	1–5 years	82.4%	NA

ABBM: Anorganic bovine bone mineral; EMD: Enamel matrix derivative; NA: Not applicable; PRF: Platelet-rich fibrin; PRP: Platelet-rich plasma

inantly achieved in the EMD group compared to the control group. They also detected new collagen fibers bridging the area from new cementum to new alveolar bone only in the EMD group. Currently, no data are available on the combined use of EMD and barrier membranes for the treatment of apicomarginal lesions in apical surgery.

The effects of EMD on tissue regeneration at the cellular and molecular levels have been extensively analyzed experimentally and clinically. Characteristic properties of EMD have been summarized by Bosshardt (29) as follows:

- It acts as a cytostatic rather than cytotoxic agent on epithelial cells.
- It stimulates the proliferation of gingival and periodontal ligament (PDL) fibroblasts.
- It increases PDL cell attachment.
- It stimulates total protein synthesis by human fibroblasts.
- It positively influences wound healing and angiogenesis.
- It has antibacterial properties (particularly its carrier propylene glycol alginate).

These multifaceted effects of EMD may explain its successful application for periodontal tissue regeneration. If root-end filling blocks bacterial leakage from the root-canal system, and no lateral canals are present, one may expect healing of apicomarginal defects providing that epithelial downgrowth along the denuded root surface can be prevented. In this respect, EMD may be superior to other regenerative techniques since it has a cytostatic effect on epithelial cells (29).

Considering the data from previous clinical studies on the treatment of apicomarginal defects in conjunction with apical surgery (Table 2), each study has analyzed a different treatment approach, but interestingly, reported similar success rates. This observation may point to the fact that the sealing of the root end is the decisive factor irrespective of the applied regenerative technique. Since only one study had a control group, no definitive conclusions can be made at this stage. Due to the retrospective nature of the present analysis and limited sample size, the results must be interpreted with caution. More studies are warranted to examine this clinically relevant issue in apical surgery.

CONCLUSION

The application of EMD resulted in a similar outcome compared to previously published clinical studies related to the use of regenerative techniques for the treatment of apicomarginal defects in conjunction with apical surgery.

Disclosures

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Informed Consent: Not applied.

Peer-review: Externally peer-reviewed.

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Authorship contributions: Concept – T.V.A.; Design – T.V.A.; Supervision – T.V.A., D.B.; Materials – T.V.A.; Data collection &/or processing – T.V.A.; Analysis and/or interpretation – T.V.A., D.B.; Literature search – T.V.A., D.B.; Writing – T.V.A., D.B.; Critical Review – T.V.A., D.B.; Final proof review – T.V.A., D.B.

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