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Clinical Innovation

Treatment of class III multiple gingival recessions: a randomized-clinical trial

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Abstract

Background: The aim of this controlled randomized split-mouth study was to evaluate whether a modified tunnel/connective tissue graft (CTG) technique – enamel matrix derivative (EMD) combination will improve the treatment of multiple class III recession when compared with the same technique alone.

Materials and Methods: Twenty healthy subjects with a mean age of 31.7 years, were enrolled for the trial in a university periodontal clinic. Patients with at least three adjacent gingival recessions on both sides of the mouth were treated with a modified tunnel/CTG technique. On the test side, an EMD was used in addition. Clinical parameters were measured at baseline, 28 days, 3, 6 and 12 months after the surgery. Results are presented at the subject level.

Results: The mean root coverage from baseline to 1 year post-surgery was 82% for the test group and 83% for the control group. Complete root coverage was achieved at 1 year in eight (38%) of the 20 surgeries (experimental and control group).

Conclusions: One-year results indicate that the modified tunnel/CTG technique is predictable for the treatment of multiple class III recession-type defects. The addition of EMD does not enhance the mean clinical outcomes.

Key words: connective tissue graft; coronally advanced modified tunnel; enamel matrix derivative; miller's class III recessions; multiple gingival recessions

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Gingival recession may be a concern for patients for a number of reasons. In addition to root hypersensitivity, erosion and root caries, aesthetic considerations may also come into play (Wennström 1996), particularly in those patients who have a high-lip smile line. Pre-disposing factors for soft tissue recession are a thin gingival biotype, prominence of teeth and patients with obsessive oral hygiene (Serino et al. 1994).

Conflict of interest and source of funding statement

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The predictability of treatments aimed to provide root coverage in cases of localized gingival recessions (LGR) has been reviewed extensively in a systematic review (Roccuzzo et al. 2002, Cairo et al. 2008, Chambrone et al. 2009) of Miller's class I and II recession defects (Miller 1983). Recently, new techniques have been proposed for the surgical treatment of multiple adjacent recession type defects (MARTD). These are mainly derived from the coronally advanced flap (CAF) (Zucchelli & De Sanctis 2000), a supraperiosteal envelope technique (SET) in combination with a subepithelial connective tissue graft (CTG) (Allen 1994a), or its evolution as a tunnel technique (Azzi & Etienne 1998, Zabalegui et al. 1999, Tozum & Dini 2003). The main goal of these plastic periodontal surgery procedures is to obtain root coverage and an optimal aesthetic appearance with complete root coverage and blending of the mucosa and/or gingiva. To increase the efficacy of the root coverage treatment and to reduce the morbidity of the technique, proposals have been made for the addition of biological factors such as enamel matrix derivative (EMD) (Pilloni et al. 2006), platelet-rich fibrin (Aroca et al. 2009), the use of acellular dermal connective tissue allograft instead of CTG to support the gingival margin and change the gingival biotype (Henderson et al. 2001) and the combination with bioabsorbable membranes (Cangini et al. 2003). Improved outcomes have also been claimed with the use of microsurgical techniques (Zuhr et al. 2007), an extension of the CTG

(Ribeiro et al. 2008) and full coverage of the grafted soft tissue or substitute (Azzi & Etienne 1998).

Case studies have been published for the treatment of multiple Miller's class I and II recession defects (Zabalegui et al. 1999, Zucchelli & De Sanctis 2000, 2005, Henderson et al. 2001, Tozum & Dini 2003, Berlucchi et al. 2005, Carvalho et al. 2006, Chambrone & Chambrone 2006, Dembowska & Drozdzik 2007, Murata et al. 2008). Comparison has been made between surgeons with different professional experience (Georges et al. 2009) and limited randomized-controlled trials have compared surgical alternatives (Henderson et al. 2001, Aroca et al. 2009).

Surgical treatment of MARTD Miller's class III defects is more challenging, mainly due to loss of inter-proximal bone and soft tissues. There are additional anatomical characteristics that are of paramount importance when compared with Miller's class I and II recessions. These include increased avascular surfaces, increased root prominence, reduced periosteal bed and, sometimes, deeper periodontal pockets.

Classifications of root recession indicate the difficulty of obtaining favourable surgical outcomes, especially in cases of class III and IV recession defects (Miller 1983, Wennström 1996). Treatment techniques similar to those for Miller's class I and II recessions are proposed for class III recessions (Cueva et al. 2004). When optimal MARTD root coverage is considered, we are dealing, mostly, with case reports where the envelope technique, in combination with a subepithelial CTG (Sato et al. 2006), or a tunnel technique (Zabalegui et al. 1999) has been used. A combination technique, with a subepithelial CTG, may improve inter-proximal soft tissue support, while the clinical benefit of adding EMD could not be evaluated on these limited cases. There is a lack of evidence for changes in the dimensions of papillae but an increased thickness of marginal gingiva (Muller et al. 1998) and a significant gain in the width of keratinized tissue (KGW) has been observed (Carvalho et al. 2006).

One advantage of the SET procedure is to preserve the continuity of the gingival papillae by creating a pouch to contain a CTG, which is slightly exposed over the recession (Allen 1994a). The pouch is created by separating the alveolar mucosa from the bone underlying the papilla, to a position beyond the muco-gingival line, by blunt dissection using curettes. By positioning this pouch and tunnel coronally, it is possible to completely cover the CTG (Azzi & Etienne 1998). In the case of Miller's class III and IV recession defects, this coronally advanced modified tunnel (CAMT) technique can be further improved by gently separating the entire inter-proximal papilla from the bone, which allows an even more coronal positioning in order to cover the defect (Azzi & Etienne 1998).

EMD, obtained from porcine embryogenesis, is an amelogenin derivative (Hammarstrom 1997) that has been developed to promote periodontal regeneration. A systematic review on EMD has shown this regenerative potential in the treatment of intra-bony defects (Esposito et al. 2005) and an additional gain of clinical attachment has been shown when compared with open flap debridement alone (Esposito et al. 2003, Pagliaro et al. 2008, Sculean et al. 2008). Less recession was found with EMD when compared with a guided tissue regeneration technique for the treatment of intra-bony defects (Sculean et al. 1999). Its biological potential was then tested with a CAF for the treatment of gingival recessions. However, there is conflicting data for root coverage of Miller's class I and II recession defects, with or without EMD. A benefit for the addition of EMD to a CAF has been found in some studies (Spahr et al. 2005, Pilloni et al. 2006), while others did not find any difference between the two groups (Modica et al. 2000, Hagewald et al. 2002, Del Pizzo et al. 2005). A CAF–EMD combination was associated with an improved root coverage when compared with a CAF–CTG (Nemcovsky et al. 2004), while an opposite result was found after a 2-year follow-up study (Moses et al. 2006). According to a systematic review, one of the benefits of EMD may be to improve CAF predictability (Cheng et al. 2007).

Histological results support these clinical conclusions. Using EMD, evidence of periodontal regeneration was first described for the treatment of an artificially created buccal dehiscence (Hammarström et al. 1997). New cementum, new periodontal ligament and new bone were reported after recession defects were treated with a CAF–EMD combination (McGuire & Cochran 2003), and also with CAF–CTG–EMD (Rasperini et al. 2000) but a more limited regeneration with the latter combination was found in four biopsies (Carnio et al. 2002). The management of class III recession defects, combined with inter-proximal bone loss and cervical recession presents a complex challenge to the periodontist for the regeneration for soft tissues and bone.

The aim of this randomized, controlled, split-mouth study is to evaluate whether the addition of EMD to a CAMT technique with subepithelial CTG will improve the treatment outcome of Miller's class III recession defects for root coverage and papillary soft tissue remodelling after 1 year.

Materials and Methods

Sample-size calculation

Using root coverage percentage as the primary outcome variable and assuming that the standard deviation (SD) of the differences in the paired measurements would not exceed 30%, the sample size for paired continuous data were calculated to be 18 subjects per treatment group (Julious & Campbell 1998). This would provide 80% power to detect a true difference of 20% between test and control. To allow for possible dropouts, 20 patients were finally recruited.

Subject selection

Twenty subjects (mean age 31.7 years), with multiple Miller's class III recession defects (Miller 1983), representing 139 recession type defects, were enrolled in the study after having signed informed consents.

The study was performed between January 2006 and December 2007 in the Department of Periodontology of Semmelweis University (Budapest), in accordance with the Helsinki Declaration of 1975, as revised in 2002. Criteria for subject selection were as follows: (1) the presence of at least three adjacent gingival recessions (defect depth >2 mm with at least one defect $\geqslant 3$ mm) on both sides of the maxillary or mandibular arch; (2) no systemic diseases that could influence the outcome of the therapy; (3) a full-mouth plaque score of $<20\%$ (O'Leary et al. 1972); (4) non-smoker; (5) not pregnant.

Study design

Oral hygiene instruction individualized for every subject was provided at the first appointment and a full-mouth supragingival scaling and polishing were per-

formed 1 month before the root coverage surgical procedure.

The study was performed according to a split-mouth design. In each patient, one side of the mandible (or maxilla) served as control and the opposite side as test. Treatment allocation was performed by the toss of a coin immediately before the surgical procedure. The same experienced practitioner (S. A.) performed both operations (at test and control sites) during a single surgical session.

All patients were given a single dose of 4 mg β-methasone (Célestène, Schering-Plough, Levallois-Perret, France) and 0.25 mg alprazolanum (Frontin, Egis, Budapest, Hungary) pre-surgically, in order to minimize post-operative oedema and anxiety. The CAMT technique used in the study has been already described (Azzi & Etienne 1998). Briefly, after local anaesthesia, the root coverage procedure, based on a modified tunnel design, was performed as follows: root planing of the exposed root surface was performed with Gracey curettes (Hu-Friedy, Chicago, IL, USA). Composite stops were placed at the contact points to prevent collapse of the future-suspended sutures into the inter-proximal spaces. Ethylenediaminetetraacetic (EDTA) was applied on the test sites, as recommended by the EMD manufacturer. No chemical was used on the control sites. Initial sulcular incisions and flap separation were then carried out with a tunnel knife – elevator instrument (Zuhr et al. 2007). The muco-periosteal dissection was extended beyond the muco-gingival junction (MGJ) and under each papilla, so that the flap could be moved in a coronal direction without tension. Muscle fibres and any remaining collagen bundles on the inner aspect of the flap alveolar mucosa were cut using Gracey curettes with extreme care in order to avoid perforation of the flap and to obtain a passive coronal positioning of the flap and the papilla.

Preparation of the donor site was performed immediately after completion of the tunnel. Dense connective tissue was harvested from the tuberosity using a distal wedge technique. Two parallel incisions were made in the retromolar area and the more palatal incision was curved at a distance of approximately 2 mm from the tooth and continued towards the mesial aspect of the second or first molar depending on the required size of the graft. The donor site was sutured with a cross-mattress suture at the tuberosity and, when needed, interrupted sutures were used to approximate the papillae (5-0 polyglactin 910, Vicryl, Ethicon, Johnson & Johnson International, St-Stevens-Woluwe, Belgium). Alternatively, when the tuberosity size was limited, a single incision was made on the palate (Hurzeler & Weng 1999) between the distal aspect of the canine and the mesial aspect of the second molar. In all cases, an adequate size of the CTG was obtained and the graft was trimmed to achieve a thickness of 1.0–1.5 mm with a no. 15 blade. Immediately after the graft was taken, pressure was applied to the donor area. Afterwards, the donor site was sutured with modified-horizontal mattress sutures. The graft was then inserted under the CAMT at the sites of recession, and retracted laterally by sutures towards each end of the tunnel in the same manner as the original SET (Allen 1994b). After positioning the CTG laterally, the site was rinsed with saline solution to remove any clot. EMD was applied to the test sites only. In all cases, the flaps were maintained in a similar coronal position, slightly coronal to the cemento-enamel junction (CEJ), with suspended sutures around the contact points (Azzi & Etienne 1998) (Fig. 1). These horizontal mattress sutures will pull the flap coronally over the CTG if there is a trend for the CTG to be exposed, or they will move both the flap margin and the CTG coronally if there is a tendency for the graft to slide apically towards the muco-gingival line.

Post-surgically, all patients were given analgesics (3×250 mg acidum nifluminicum) (Donalgin, Richter, Budapest, Hungary) for 3–4 days and antibiotics (3×300 mg Dalacin-C) (Dalacyn-C, Pfizer KFT, Budapest, Hungary) for 5 days in accordance with university regulations for implantable biological materials. Patients were informed not to brush their teeth in the operated areas until suture removal 2 weeks later. They were instructed to rinse their mouths with a 0.12% chlorhexidine solution twice a day for 1 min. for 3 weeks. Fifteen days after surgical treatment, all patients were checked and instructed in mechanical tooth cleaning of the operated areas using a soft toothbrush and a roll technique. All patients were recalled at 28 days, then at 3, 6 and 12 months for evaluation. Each time, clinical measurements were performed and subjects received one session of prophylaxis, including reinforcement of oral hygiene, supragingival debridement, and tooth polishing. The study was completed after 1 year.

Clinical assessments

The following clinical parameters were assessed at baseline, 6 months and 1 year post-operatively: plaque index (PI) (Löe 1967), gingival index (GI) (Löe & Silness 1963), probing depth (PD), gingival recession (REC) and clinical attachment level (CAL). Additionally, the width of the KGW, measured as the distance from the MGJ to the gingival margin, the width of the recession defect (RW) and the distance between the contact point and the top of the papilla at the mesial aspect of the tooth (DCP) were recorded. PD, REC, CAL and KGW measurements were performed at the mid-buccal point of the teeth involved. The same blinded calibrated examiner (T. K.) undertook all the probing measurements using a Hu-Friedy periodontal probe (PCP-UNC 15 periodontal probe, Hu-Friedy).

The CEJ was used as a reference point for these measurements, except in those cases where the CEJ was not visible, in which case, the margin of a restoration was used as a reference point.

At 28 days and at 3 months, only the measurements for REC and DCP were recorded.

Any patient concerns regarding discomfort, tooth sensitivity or aesthetic appearance, or any other complaints during the study period were also recorded. There was no assessment of these parameters by a visual analogue or numeric scale.

Intra-examiner reproducibility

Five subjects not involved in the study, each showing a pair of single-rooted contra-lateral teeth with recessions of >2 mm on the mid-buccal aspect of each tooth, were used to calibrate the examiner. The examiner evaluated the subjects on two occasions 24 h apart. Calibration was accepted if 90% of the recordings could be reproduced within a difference $\leqslant 0.5$ mm (Pilloni et al. 2006).

Statistical analysis

Statistical analysis was performed using commercially available software (Instat® 2000, version 3.05, GraphPad Software Inc., San Diego, CA, USA). A subject-level analysis was performed for each parameter. Mean values and standard

Fig. 1. Results of test and control procedures after treatment of multiple Miller's class III recessions: On the test group: (a) a radiograph showing inter-dental bone loss; (b) baseline view; (c) post-operative view: the modified tunnel/connective tissue graft is sutured after enamel matrix derivative (EMD) application and maintained in a coronally position by suspended sutures around the contact point; (d) clinical view at 28 days; (e) 3 months; (f) 6 months; (g) 1 year. On the control group: (h) a radiograph showing inter-dental bone loss; (i) baseline view; (j) post-operative view: sutures of the modified tunnel/connective tissue graft without EMD application; (k) at clinical view at 28 days; (l) 3 months; (m) 6 months; (n) 1 year.

deviations (mean $\pm$ SD) for the clinical variables were calculated for each treatment. The method of Kolmogorov and Smirnov was used to confirm that the data were sampled from a Gaussian distribution. The significance of the difference within each group and between groups before and after treatment was evaluated with the paired samples *t*-test. Ordinal data (PI, GI) were analysed using the Wilcoxon matched-pairs test. Differences were considered statistically significant when the *p*-value was <0.05.

Results

The Kolmogorov–Smirnov test of baseline data showed a homogeneous distribution of the data ($p<0.05$).

All 20 enrolled patients completed the study. No patient needed to be excluded

from the study, nor had significant complications. The data set was complete with no missing data.

As far as root sensitivity was concerned, all patients expressed improvement.

Ten patients had defects in the maxillary arch and the same number had defects in the mandibular arch. Ten subjects had sites involving only anterior teeth (five on the maxilla and five on the mandible). Seven subjects had sites that also involved bicuspids (two in the maxilla and five in the mandible) and three subjects had sites involving maxillary bicuspids and molars.

The values of the clinical parameters at baseline, 6 months and at 1 year are shown in Table 1. No statistical difference was observed within and between groups for PI, GI, PD or KGW values between baseline, 6-month and 1-year measurements.

Both treatment groups showed significant post-surgical improvement in the coverage of REC and CAL gain, when compared with baseline.

At the subject level, for the test group, the mean recession depth decreased significantly from 3.5 ± 1.5 mm (baseline) to 0.6 ± 0.9 mm (28 days) and to 0.8 ± 1.1 mm (1 year), with slight variations for measurements at the other time intervals. The corresponding results for the control group were; 3.2 ± 1.4, 0.6 ± 0.8 and 0.6 ± 0.9 mm (Fig. 2). Also, both treatments resulted in a significant CAL gain (3.11 and 2.86 mm for test and control groups, respectively). REC coverage and CAL gain were not significantly different between the two groups. Statistically significant decreases in RW and DCP measurements were observed between the baseline, the 6-month and 1-year data, but these results were not statistically different between the two treatment groups (Table 1).

When the results were expressed as a percentage of root coverage at 1 year, both treatments resulted in a root coverage of 82% and 83% for test and control groups, respectively (Table 2). After 1 year, the gain in the vertical height of the papilla (as measured by the reduction of the DCP distance), when expressed as a percentage, was 58.6% and 59.2% for test and control groups, respectively. Mean mesial and distal probing were, respectively, 1.9 ± 0.7, 2.0 ± 0.7 mm at baseline for the test group, 2.0 ± 0.6, 2.1 ± 0.6 mm for the control group, respectively. These values were not statistically different between groups and no significant differences were also found at 1 year between groups and baseline measurements (Table 3).

Table 1. Mean and SD of all evaluated parameters in the operated patients at baseline, 6 and 12 months post-operatively

	Baseline	6 months post-operatively	1 year post-operatively	*p*-value
PI (1–3)				
Test ($n = 20$)	0.1 ± 0.1	0.1 ± 0.1	0.2 ± 0.3	>0.999
Control ($n = 20$)	0.1 ± 0.1	0.1 ± 0.1	0.2 ± 0.2	>0.999
p-value	>0.999	>0.999	>0.999	
GI (1–3)				
Test ($n = 20$)	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.2	>0.999
Control ($n = 20$)	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	>0.999
p-value	>0.999	>0.999	>0.999	
REC (mm)				
Test ($n = 20$)	3.5 ± 1.5	0.6 ± 0.9	0.8 ± 1.1	<0.001
Control ($n = 20$)	3.2 ± 1.4	0.6 ± 0.8	0.6 ± 0.9	<0.001
p-value	0.51	>0.999	>0.999	
CAL (mm)				
Test ($n = 20$)	4.8 ± 1.9	1.7 ± 1.0	1.9 ± 1.1	<0.001
Control ($n = 20$)	4.7 ± 1.7	1.8 ± 0.9	1.9 ± 1.0	<0.001
p-value	0.858	0.735	>0.999	
PD (mm)				
Test ($n = 20$)	1.4 ± 0.7	1.1 ± 0.4	1.2 ± 0.4	0.264
Control ($n = 20$)	1.5 ± 0.7	1.2 ± 0.5	1.3 ± 0.5	0.294
p-value	0.645	0.478	0.478	
KGW (mm)				
Test ($n = 20$)	2.5 ± 1.4	2.7 ± 1.0	2.6 ± 1.2	0.805
Control ($n = 20$)	2.6 ± 1.3	2.8 ± 1.1	2.7 ± 1.2	0.797
p-value	0.812	0.759	0.788	
RW (mm)				
Test ($n = 20$)	3.8 ± 1.5	1.2 ± 1.7	1.3 ± 1.7	<0.001
Control ($n = 20$)	3.6 ± 1.4	1.3 ± 1.6	1.3 ± 1.8	<0.001
p-value	0.657	0.845	>0.999	
DCP (mm)				
Test ($n = 20$)	2.9 ± 1.4	1.7 ± 1.5	1.7 ± 1.2	0.004
Control ($n = 20$)	2.7 ± 1.3	1.6 ± 1.3	1.6 ± 1.2	0.007
p-value	0.634	0.819	0.788	

PI, plaque index; GI, gingival index; REC, gingival recession; CAL, clinical attachment level; PD, probing depth; KGW, width of keratinized gingival; RW, width of recession defect; DCP, distance the contact point and the top of papilla at the mesial aspect of the tooth.

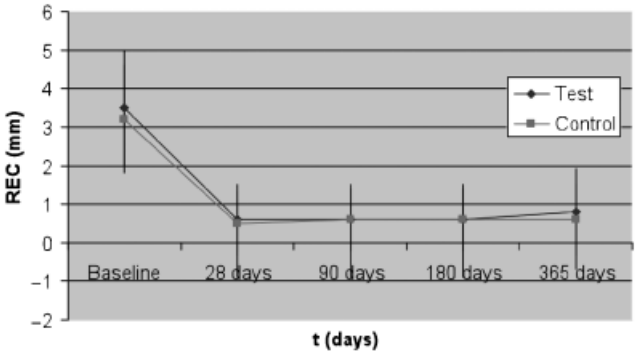

Fig. 2. Mean change (± SD) in recession from baseline to 28, 90, 180 and 365 days. The data for each group were calculated at the patient level. There was no statistical difference between groups when evaluated with the paired sample *t*-test.

At 28 days, complete root coverage (100%) was observed in eight (38%) and seven (33%) of the test and control group surgeries, respectively. At the

Table 2. Mean and SD of the root coverage percentage and complete root coverage in the operated patients at 12 months post-operatively

	Root coverage (%)	Complete root coverage
Test ($n = 20$)	82 ± 25	8/20
Control ($n = 20$)	83 ± 26	8/20
p-value	0.90	1.0

Table 3. Mean and SD of mesial and distal probing depth (PD) at baseline and in the operated patients at 12 months post-operatively

	Baseline	1 year post-operatively	*p*-value
PD mesial			
Test ($n = 20$)	1.9 ± 0.7	1.8 ± 0.7	0.101
Control ($n = 20$)	2.0 ± 0.6	2.1 ± 0.6	0.497
p-value	0.264	0.064	
PD distal			
Test ($n = 20$)	2.0 ± 0.7	1.9 ± 0.6	0.121
Control ($n = 20$)	2.1 ± 0.6	1.9 ± 0.6	0.071
p-value	0.556	0.655	

Table 4. Frequency of root coverage between the groups after 28 days and 1 year post-operatively

Mean root coverage per surgery	100%		99–75%		74–50%		49–0%	
Time of evaluation	28 days	1 year	28 days	1 year	28 days	1 year	28 days	1 year
Test group ($n = 20$)	8	8	8	6	2	4	2	2
Control group ($n = 20$)	7	8	8	8	4	3	1	1

1-year assessment, complete root coverage was observed in eight of the surgeries in each of the two groups. Nine of the surgeries in each group resulted in coverages in the 99–75% range at 28 days, but only seven at 1 year for the test group. The distribution of surgeries according to the percentage of root coverage is shown in Table 4. Among those patients with 100% root coverage on the control side at 1 year, five showed similar results on the test side.

Discussion

This RCT study is challenging for two clinical reasons. To our knowledge, no RCT study has been published previously that involves Miller's class III recession defects exclusively. Also, the fact that we are dealing with multiple bilateral recessions increases the surgical difficulty and the risk of failure when compared with monolateral and single recessions (Clauser et al. 2003).

Altogether 139 recessions were treated, 69 in the test group and 70 in the control group. We chose a patient-level analysis, instead of selecting the deepest recession from a surgical site. This approach may be more clinically relevant, because it will allow an appreciation of clinical outcome by surgery.

When needed, bicuspids and molars have been included in the surgical field. These posterior sites may be of concern for patients because of root sensitivity or, in the case of patients with a high-lip smile line, because of aesthetics. There were two sites with molar involvement in the test group and three in the control group. For bicuspids, the numbers were 17 and 12, respectively. The small number of molars in our study is likely to have had little effect on the overall data, but the inclusion of bicuspids will include sites with a wider bucco-lingual inter-proximal bone morphology, than is the case with the cuspid to cuspid sites. In our study, the patient mean percentage of root coverage for the two groups is at least of 82%. This compares favourably with the 85.7% (at a patient level), obtained in the SET original paper for multiple Miller's class I and II recession defects (Allen 1994b). This figure has been extrapolated from his data on seven patients who had recessions at two to five sites. Individual data were also obtained in a case series that compared results following treatment by three surgeons of various clinical experience. After 6 months and each surgeon using the same technique, root coverage was 80%, 85% and 89% (Georges et al. 2009).

The CAMT technique is quite predictable for root coverage of class III recession defects and, in many cases, provides full-root coverage. The argument that success may be obtained only occasionally (Miller 1983, Wennström 1996), can be challenged, because a similar predictability to the treatment of class I and II recessions by MARTD has been obtained. This result may be due to a number of factors. Firstly, in our technique (Fig. 3), the muco-periosteal tunnelized envelope flap was carefully released beyond the muco-gingival line and the collagen bundles, preventing the flap from being moved coronally, were separated by curettes to obtain an effect similar to that of a horizontal releasing incision in the advanced flap technique. Secondly, in order to promote revascularization of the graft, the CTG was completely submerged (Guiha et al. 2001). Stabilization of the CTG beneath the CEJ was provided, when needed, by mattress sutures suspended around the contact point. Thirdly, the papillae were carefully released from the underlying bone. Fourthly, the use of suspended sutures around the contact point provides good coronal stabilization of the flap during the first 2 weeks of wound healing. The beneficial effect of these sutures has also been found for class I and II recessions after the coronally positioned envelope flap procedure (Aroca et al. 2009) and an increased complete root coverage was found when advancing the flap over the CEJ of LGR (Pini Prato et al. 2005).

Chemical root conditioning was used in our study on the test sites before tunnel preparation mainly to avoid the presence of chemical beneath the papilla and the flap margin of the CAMT. In our protocol, only the exposed root surfaces of the test teeth are conditioned, whereas the root surfaces beneath the gingival margins and papillae are rinsed with saline solution only, as for the control sites. The stated clinical benefit of the EDTA protocol, to remove the smear layer to expose the collagen fibres of the cementum and to allow precipitation of EMD on a root surface free of organic elements (Blomlof et al. 1997), has been challenged by two systematic reviews, which conclude that the clinical outcome does not depend on the use of root conditioning (Mariotti 2003, Cheng et al. 2007). However, in a systematic review on the use of CAF for localized recessions, CAF alone and CAF with chemical root conditioning (EDTA) were considered unpredictable for root coverage when compared with CAF+EMD+EDTA (Cheng et al. 2007).

The two groups show a statistical mean DCP gain when compared with

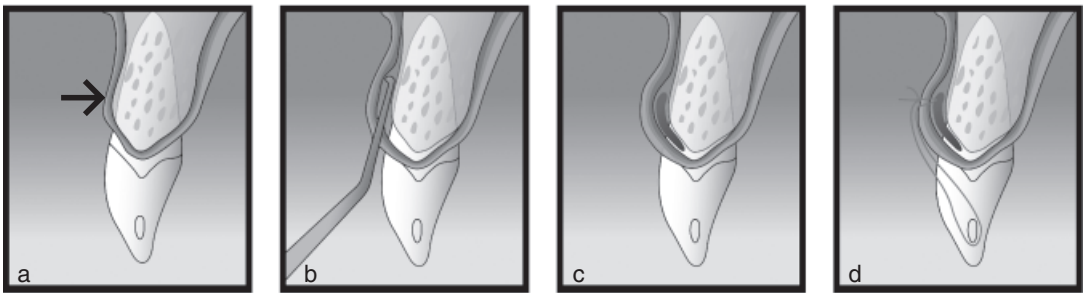

Fig. 3. Diagram of the critical surgical steps: (a) Initial gingival recession – muco-gingival line (arrow). (b) A gingival pouch and tunnel is dissected beyond the muco-gingival line and the collagen bundles are separated by curettes beneath the elevated flap. Papilla are then released. (c) The connective tissue graft is placed slightly beneath the cemento-enamel junction and its cervical position is determined by the sutures at each end of the graft. (d) The flap submerge completely the connective tissue graft and is maintained in a coronal position by sutures around the contact point. These sutures may or may not go through the graft, depending on the need for a coronal or inter-proximal displacement of the connective tissue graft.

baseline. However, there is a discrepancy between the mean root coverage and papillary gain. The significance of anatomical features of the papillae, such as soft tissue thickness, alveolar bone height and their relationship with root coverage could not be determined for class I and II recessions (Berlucchi et al. 2005) and further studies are needed for cases that involve inter-proximal soft tissue and/or bone loss.

This failure to obtain a papillary gain similar to the amount of root coverage may be due to lack of inter-dental support with a CTG flat strip and/or regeneration. With localized papillary defects, a dense subepithelial CTG with a pyramidal shape from the tuberosity (Azzi et al. 1999, Nordland et al. 2008) will help to support the papilla, but with MARTD and a palatal donor site, we cannot customize the graft for each inter-proximal space. The subepithelial CTG is beneficial for gingival margin stabilization, but inter-proximally, after an initial swelling of the soft tissue, which sometimes fills the inter-dental space, there is a shrinkage of soft tissue during wound healing. This effect is more pronounced for class IV recession defects that have a wider distance between the crestal inter-proximal bone and the contact point. It has been reported that with a localized and wide inter-proximal space, the use of a bone graft provided some papillary gain, but further papilla enhancement was made possible only by reduction of the inter-dental tri-dimensional space with veneers (Azzi et al. 2001).

There is a nearly threefold reduction of RW for both the test and control groups (Table 1). This result is obtained in spite of a lack of inter-proximal bone support, and may be due to the support of the gingival margin and papilla provided by the subepithelial CTG, which may be slightly stretched in the inter-proximal spaces by the suspended sutures.

Interestingly, the combined use of CTG with EMD is not associated with any improved gain in root coverage or reduction of DCP. This lack of beneficial effect of EMD with a CAMT technique on root coverage after 1 year may be linked to the high efficacy of the subepithelial CTG (Chambrone et al. 2008) when compared with EMD efficacy. It is also possible that in some specific clinical or anatomical situations, we lack discriminating tools for the evaluation of early signs of regeneration. The need for a longer period of observation has been claimed for EMD treatment on LGR (Pilloni et al. 2006). When LGR were treated of with CAF–EMD, *versus* CAF alone, there were no significant differences between the groups (Hagewald et al. 2002). But after 2 years, complete root coverage was maintained in 53% of the test sites, compared with 23% in the control group (Spahr et al. 2005). This improved stability with EMD treatment over time is not apparent within the time frame of our study. When complete root coverage was considered to be the primary outcome variable in a systematic review on CAF, single combination and LGR, definitive conclusion cannot be drawn on the advantage of EMD *versus* CTG and there is a need for RCTs with high power (Cairo et al. 2008). Where complete root coverage was obtained in the test group, this had been achieved by 28 days. In the control group, one case showed a creeping attachment. Where the percentage root coverage was in the range 99–75%, the control group surgeries remain stable, while in the test group, two surgeries showed a decrease in root coverage over time.

Clinically, the limited PD (Table 1) observed in the two groups may reflect the beneficial effect of the subepithelial CTG adhesion, which has been described previously (Bruno & Bowers 2000). The subepithelial CTG–EMD combination may not yield such predictable results in promoting periodontal regeneration, or its potential to inhibit the development of a long junctional epithelium (Carnio et al. 2002) cannot be evaluated clinically.

There was no significant KGW increase between the two groups or when compared with baseline. An increase of 1.52 ± 1.05 mm was reported in a systematic review on LGR with subepithelial CTG (Oates et al. 2003), with a greater increase when the graft was left uncovered (Ouhayoun et al. 1988, Bouchard et al. 1994, Han et al. 2008). This change in KGW may be technique dependent (Cairo et al. 2008). A smaller KGW increase was found with a CAF when compared with an envelope flap (Cordioli et al. 2001). With MARTD and a tunnel technique leaving the CT graft exposed, a KGW increased was found after 3 years (Ribeiro et al. 2008, case report).

For LGR Miller's class I and II, a KGW increase was statistically significant at 18 months for a CAF–EMD group (Pilloni et al. 2006). It was more pronounced in a CAF–EMD group when the subepithelial CTG was left exposed. In our study, the mean KGW at baseline was 2.5 and 2.6 mm for the test and control group, respectively, and the mean values at patient level were comparable during the observation period. This lack of effect may be due to the spatial configuration of the subepithelial

CTG with the CAMT technique and its suspended sutures during a 2-week period, which may change the inductive signals from the CTG on epithelial differentiation during the early period of wound healing (Karring et al. 1975, Ouhayoun et al. 1988).

A 1-year period of evaluation may be sufficient to evaluate the efficacy of a CAMT technique for the surgical treatment of class III gingival recessions, but a longer period of evaluation is probably necessary to assess whether these initial positive results are modified with time. Traumatic toothbrushing habits may cause interference on an immature or thin gingival margin, and the time frame may be too short to evaluate the biologic potential of the subepithelial CTG and EMD for inter-proximal hard and soft tissue regeneration or the quality of attachment.

Conclusion

Within the limits of the study design and the sample size of this randomized, controlled, blinded clinical study, the following results have been found. At 1 year, the CAMT technique gives predictable results for the treatment of multiple Miller's class III recession defects. The addition of EMD, in combination with a CTG did not enhance the mean clinical outcome when compared with a similar technique without EMD on the control side. Stable results were obtained by 28 days and there was no significant difference within and between groups for the position of the gingival margin and papilla from 28 days to the 1-year measurement period.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Supporting information in accordance with the CONSORT Statement 2001 checklist used in reporting randomized trials.

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Clinical Relevance

Scientific rationale: Multiple class III gingival recessions represent a challenge for root coverage, due to interproximal crestal bone and papilla loss. EMD may improve root coverage outcome and papilla fill.
Principal findings: At patient level, a coverage of multiple class III gingival recessions is predictably obtained with a CAMT/CTG technique. However, the magnitude of soft tissue papilla improvement is reduced when compared with root coverage. Within the limits of this study, the combined used of EMD is not associated with any apparent clinical improvement for percentage of root coverage, full coverage or papilla fill.
Practical implications: With a CAMT/CTG technique, root coverage can be predictably obtained in spite of class III multiple gingival recessions.