Treatment of Multiple Gingival Recessions Using a Minimally Invasive Coronally Advanced Tunnel: A Randomized Controlled Clinical Trial

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Abstract

Aim: The purpose of this trial was to evaluate the outcome of a modification of pin hole surgical technique which consists of a minimally invasive coronally advanced tunnel technique (MICAT) with orthodontic buttons and suturing in the treatment of multiple recession type defects.

Materials and methods: Twelve systemically healthy patients (79 sites) aged between 22 - 55 years with Miller's Class I and II multiple recession defects were treated with minimally invasive coronally advanced tunnel technique. Thirty-nine sites were randomly assigned to a control group and the other 40 sites to the test group. In the test group, in addition to the MICAT procedure, buttons and suspensory silk sutures were used for the stabilization of the advanced flap. Clinical parameters were assessed at baseline, 3 weeks, 6 weeks and 6 months after surgery.

Results: A total of 79 recessions were treated. Complete root coverage from baseline to 6 months was 56% in the control group and 73% in the test group. Mean root coverage was 82.4% in the control group and 85.7% in the test group. Root coverage aesthetic scores of 9.3/10 and 9.4/10 were noted in the control and test group respectively.

Conclusion: Six months post-surgical evaluation showed that minimally invasive coronally advanced tunnel technique with orthodontic buttons and suturing was effective and predictable for the treatment of multiple recession type defects. The clinical outcomes were similar to that of the control group with no statistical difference between the two groups.

Key words: Multiple recession type defects, coronally advanced flap, tunnel technique, aesthetics, root coverage, minimally invasive

Introduction

Gingival recession defects that commonly occur in the buccal surfaces are predominantly caused by traumatic tooth brushing, tooth mal-positioning, and ectopic insertion of frenum and muscle attachment (Chambrone *et al.,* 2009), and are also related to plaque-associated chronic inflammatory periodontal disease (Cetiner *et al.,* 2004). Multiple recessions are more challenging to treat as compared to isolated gingival recessions. The choice of the treatment option and the final outcome with different surgical procedures is dictated by a variety of factors such as depth of recession, defect size, nature/quantity of keratinized tissue adjacent to the defect, width and height of interdental soft tissue, vestibular depth (Pini-Prato *et al.,* 2010), post-operative stabilization and final coronally advanced position of the gingival margin. The final position of the gingival margin plays a critical role in achieving complete root coverage (CRC) and long-term maintenance of recession management outcome (Pini Prato *et al.,* 2005).

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The scientific literature is replete with treatment protocols for management of multiple recession type defects (MRTDs) that include coronally advanced flap (CAF), modified CAF technique (Zucchelli and De Sanctis, 2000) modified CAF with an sub-epithelial connective tissue graft (CAF + SCTG; Allen, 1994; Pini-Prato *et al.,* 2010), CAF with connective tissue graft (CAF + CTG; Cortellini *et al.,* 2009; Pini-Prato *et al.,* 2010) CAF with orthodontic buttons (Ozcelik *et al.,* 2011) expanded mesh technique (Cetiner *et al.,* 2004), vestibular incision sub-periosteal tunnel access technique (VISTA; Zadeh, 2011), CAF with and without vertical releasing incisions (Zucchelli *et al.,* 2009), and the pinhole surgical technique (PST; Chao, 2012). It is a continuously evolving and expanding field of research. The evidence for multiple gingival recessions is limited. Modified CAF and tunnel approaches show higher level of complete root coverage (CRC), and CAF plus graft show the best results (Graziani *et al.,* 2014). These surgical techniques have shown CRC in 35-90% of recession defects (Chambrone *et al.,* 2009; Pini-Prato *et al.,* 2010). Among all these techniques, CAF + CTG have provided the best root coverage outcome.

A surgical technique that addresses all the recession defects in a single surgical visit, that is operator friendly, easy, practical, time efficient, not requiring a second surgical site, and, most importantly, meets the patient's aesthetic demands is a desirable option. (Ozcelik *et al*., 2011; Zucchelli *et al*., 2010). The pinhole surgical technique (Chao, 2012) is one such minimally invasive technique for recession coverage in MRTD. The entire procedure can treat 3-10 recession defects with minimal incision (Chao, 2012). However, this technique does not employ suturing to anchor the displaced flap. The most critical part of any perio-plastic surgery for recession coverage is the anchorage and stabilization of the displaced flap achieved during the first two weeks of wound healing (Ozcelik *et al*., 2011). Coronally advanced flap with button application, composite stops for stabilization of sutures and coronal stabilization of advanced flap showed better results than CAF alone in treatment of MRTD (Ozcelik *et al.,* 2011). It has been shown that the greater post-operative displacement of gingival margin may cause greater root coverage (Pini Prato *et al.,* 2005; Pini-Prato *et al.,* 1999). The large avascular surgical area with MRTD may be associated with morphological variations such as root anatomy, root proximity, vestibular depth, gingival biotype, etc. Vertical incisions in such areas would compromise the revascularization of the surgical area and hamper the clinical outcome. A technique that eliminates the need for vertical releasing incisions while maintaining the integrity of interdental papilla will favor better vascularity and aesthetics.

Suturing protocol to anchor and stabilize the displaced flap helps in achieving increased CRC. Better root coverage outcomes were reported when flap anchorage was established via suturing (Marggraf *et al.,* 1985; Romanos *et al.,* 1993). Hence, we adopted a modification of the PST – the minimally invasive coronally advanced tunnel technique (MICAT) that includes buttons and suturing. The purpose of this randomized controlled clinical trial was therefore to investigate the efficacy of this novel treatment strategy.

Materials and methods

Study design

The present study is a human, prospective, single centre, single blind, split-mouth, comparative controlled randomized clinical trial for the treatment of Miller's Class I and II MRTDs, comparing the clinical outcomes prior to and after 6 months of treatment. The trial is in accordance to the Consolidated Standards of Reporting Trials (CONSORT) criteria, 2010. The trial has been registered with ClinicalTrials.gov ID: NCT02632968.

Source of data

Patients referred to the outpatient Department of Periodontology, Krishnadevaraya College of Dental Sciences and Hospital, Bangalore, India, and those satisfying the inclusion and exclusion criteria were selected for the study. The study duration was from October 2013 to January 2015.

Sample size

Sample size was calculated using root coverage as a primary outcome variable and assuming standard deviation of differences in the paired measurement should not exceed 15%. A sample size of paired continuous data was calculated to be 37 sites in each study group (Ozcelik *et al.,* 2011). This would provide 95% power to detect a true difference of 5% between test and control study groups to allow for possible dropouts. The prospective, comparative controlled randomized clinical trial thus enrolled 40 recession defects in the test group and 39 in the control group, within a 95% confidence limit and 95% power.

Subject selection

Seventy-nine recession defects were selected in 12 patients who were systemically and periodontally healthy, satisfying the determined inclusion criteria. Patients with at least two or three (Zucchelli and De Sanctis, 2005) teeth having Miller's class I, II or combination of class I and II recession defects (Ozturan *et al.,* 2011) in the maxillary arch were included in the study. A detailed, thorough medical and dental history was obtained and each patient was subjected to comprehensive clinical and radiological examination. All patients were informed about the nature of the study, surgical procedure involved, potential benefits and risks associated with the surgical procedure and a written informed consent was obtained from all patients.

The study was strictly conducted in accordance with the principles of World Medical Association, Declaration of Helsinki (version 2008) and the study protocol was reviewed and approved by the institutional ethical committee and review board (REF:KCDS/168a/2013-2014) of Krishnadevaraya College of Dental Sciences and Hospital, Bangalore, India, affiliated to Rajiv Gandhi University of Health Sciences (RGUHS).

Inclusion and exclusion criteria

Patients in the age group 25 - 55 years (Pini-Prato *et al.,* 1999) fulfilling the following criteria were included in the study: Multiple (at least two or three) Miller's class I and II or combined class I and II recession defects (Chao, 2012) affecting adjacent teeth of the maxillary arch, patients with thick gingival biotypes > 0.8 mm (Baldi *et al.,* 1999), presence of adequate keratinized tissue apical to recession > 1 mm (Ozcelik *et al.,* 2011), systemically healthy (American Society of Anaesthesiologists Physical Status I or II; Chao, 2012; Maloney and Weinberg, 2008), no contra-indications for periodontal surgery (Zucchelli and De Sanctis, 2000), non-smokers (Trombelli *et al.,* 2009; Chambrone *et al.,* 2009), patients with aesthetic concerns (Zucchelli and De Sanctis, 2005), patients with history of compliance with oral hygiene instructions and a full mouth plaque score of < 10% (O'Leary 1972).

Patients with the following criteria were excluded from the study: Recession defects associated with caries/demineralization and deep abrasions (step > 2 mm; Ozcelik *et al.,* 2011), occlusal interferences (Ozcelik *et al.,* 2011), teeth with evidence of pulpal pathology (Ozcelik *et al.,* 2011), patients who had undergone any previous periodontal surgical procedures at the involved sites (Chao, 2012), pregnant and lactating women and patients on medications known to interfere with periodontal tissue health or healing (Zucchelli *et al.,* 2009).

Objective

The primary objective of this study was to evaluate the effectiveness and predictability of MICAT that includes orthodontic buttons and sutures in the treatment of multiple adjacent recession defects.

The secondary objectives of the study were to assess the influence of these surgical procedures on the gingival and periodontal health.

Clinical measurements

All clinical measurements were carried out by a single masked/blinded examiner to ensure an unbiased evaluation. Prior to the study, the examiner was calibrated to decrease intra-operator bias by the evaluation of study parameters on two separate occasions on 10 patients. Calibration was accepted if the measurements were similar at the 90% level on both examinations (Ozcelik *et al.,* 2011; Ozturan *et al.,* 2011) to reduce intra-examiner error (kappa > 0.75) and to establish reliability and consistency in the recorded clinical measurements (Zucchelli *et al.,* 2009).

Clinical parameters

The primary clinical outcomes that were assessed at baseline, 6 weeks, 3 months and 6 months respectively were the difference in gingival recession depth (GRD), complete root coverage (CRC), mean root coverage (MRC), gingival margin (GM) location, gingival recession width (GRW) and root coverage aesthetic score (Maloney and Weinberg, 2008).

The secondary outcomes that were assessed were differences in probing pocket depth (PD), clinical attachment level (Pini-Prato *et al.,* 1999) and width of keratinized tissue (KTW). The parameters measured were GRD, measured as the distance between the cementoenamel junction (CEJ) and the gingival margin (Ozcelik *et al.,* 2011); GRW, measured as the distance between the mesial gingival margin and distal gingival margin (measurement was recorded on a horizontal line tangential to the CEJ; Ozcelik *et al.,* 2011); PD, measured as the distance from the gingival margin to the base of the gingival sulcus (Chao, 2012); CAL (Pini-Prato *et al.,* 1999), measured as the distance from the CEJ to the base of the gingival sulcus (Chao, 2012); apico-coronal width of keratinized tissue (KTW), measured as the distance from the muco-gingival junction to the gingival margin, with the muco-gingival junction location determined using a visual method (Schiller's potassium iodide solution; Ozcelik *et al.,* 2011). Gingival margin advancement of each site was calculated by subtracting the distance between the incisal margin to CEJ from the distance between the incisal margin to advanced gingival margin achieved after suturing (Clauser *et al.,* 2003). This was calculated by photographic analysis using computer software (Image analysis software, MedCalc software bvba, Belgium).

Standardized photographs with respect to scale, shooting angle and focal length were taken. In this study, the crown width at the incisal margin of the maxillary central incisor was considered for standardization. The mid-buccal point of the gingival margin (Albandar and Kingman, 1999), incisal margin and CEJ helped to calculate the position of the GM and recession depth with computer assisted digitizing software (Koseoglu *et al.,* 2013). Gingival margin advancement beyond the CEJ was calculated by subtracting the distance between incisal margins to the advanced gingival margin after suturing (IM - GM) from the distance between incisal margin to CEJ (IM - CEJ pre-surgical). The pre-surgical and post-surgical standardized photographs were used for calculating the gingival margin advancement achieved (*Figure 1*). Root coverage aesthetic score (Cairo *et al.,* 2009), plaque index (Silness and Löe, 1964), gingival bleeding index (Ainamo and Bay, 1975) and gingival index (Löe and Silness, 1963) were recorded.

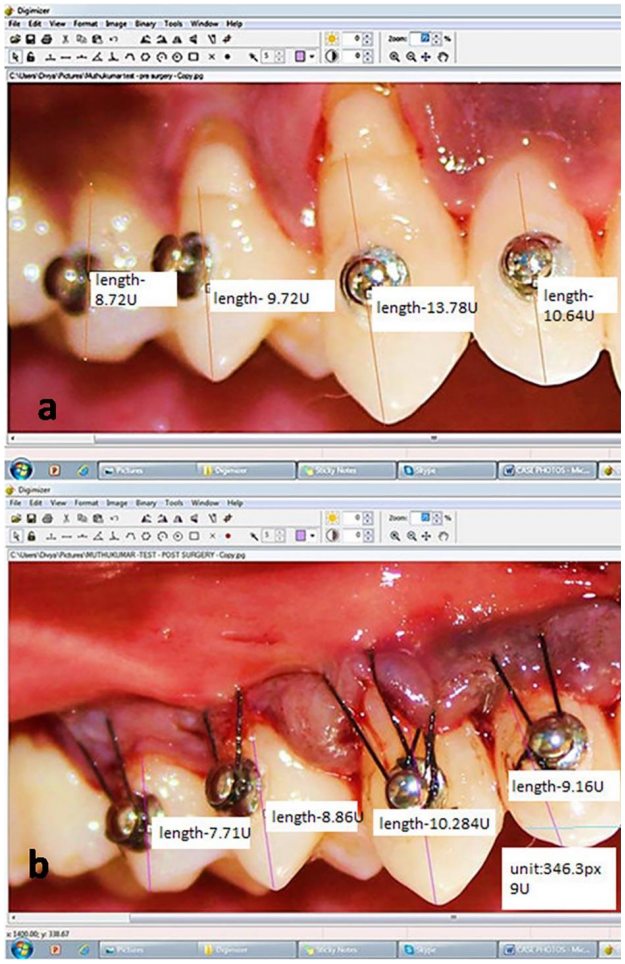

Figure 1. Assessment of gingival margin advancement by photographic analysis using computer-assisted digitizing software. Green line, crown width for standardization. Red line, distance from incisal margin to CEJ. Purple line, distance from incisal margins to advanced gingival margin after suturing. a) Pre-surgical standardized photographs used for calculating the gingival margin advancement; b) Post-surgical standardized photographs for calculating the gingival margin advancement

Bias elimination

All clinical measurements were carried out by a single, calibrated blinded examiner to ensure an unbiased evaluation and rule out inter-examiner variability. Surgical operations of test and control study groups were both performed by the same experienced operator to avoid intra-operator surgical variation (Ozcelik *et al.,* 2011).

Sampling technique and randomization

The patients were assigned to one of two treatment groups (test and control). The test group was treated with MICAT with buttons and sutures for flap advancement and stabilization; the control group did not include the button and suturing protocol.

A computer-generated randomization sequence was obtained by another staff member. Allocation concealment was achieved using a sealed coded opaque envelope containing the treatment of the specific subject (i.e, test or control). The sealed envelope containing treatment assignment was opened by the operator immediately prior to surgery to prevent surgeon bias (Ozcelik *et al.,* 2011; Zucchelli *et al.,* 2010).

Pre-treatment procedures

Surgical treatment of the recession defects was not scheduled until the patient demonstrated an adequate standard of supra-gingival plaque control (plaque score <10% O' Leary 1972). The above-mentioned clinical parameters were recorded to the nearest millimeter using a UNC-15-probe, and measuring occlusal stents for positioning the probe were fabricated with cold-cured acrylic resin on a cast model obtained from an alginate impression.

Surgical procedure

After the screening examination in the initial phase each subject received a session of oral hygiene instructions to modify habits related to the etiology of gingival recession. A coronally directed roll technique for brushing was prescribed for teeth with recession defects to minimize the toothbrushing trauma to the gingival margin (Cairo *et al.,* 2009). Initial cause-related therapy that included scaling and root planing with ultrasonic scalers and manual curettes was thoroughly done in all selected subjects one month prior to surgery (Ozcelik *et al.,* 2011).

Before starting surgery, root surfaces in the buccal surfaces were instrumented with mini-five Gracey curettes and the mechanical treatment was terminated when smooth and hard root surfaces were obtained (Ozcelik *et al.,* 2011; Zucchelli *et al.,* 2009). Extra-oral antisepsis was performed using povidone iodine solution and intra-oral antisepsis was performed using a 0.12% chlorhexidine mouth rinse (Chao, 2012; Cetiner *et al.,* 2004; Ozcelik *et al.,* 2011) For test sites, orthodontic buttons (Prime Orthodontics, Inc. Portland, OR, USA) were applied on the middle of middle one third of the crown of the tooth with dental cement (dual cure glass ionomer cement; 3M ESPE, USA) and cured with a light curing unit until hardened (Ozcelik *et al.,* 2011).

The surgical protocol employed was similar to PST™ (Chao, 2012) except for the use of the patented instrument, which was substituted with a papilla elevator (TKN2, Hu-Friedy, Chicago, IL, USA). After injection of local anesthesia (2% lignocaine hydrochloride; Lignox 2%, Indoco Remedies Ltd, Goa, India), using a No. 15 blade a minimum horizontal incision of 2-3 mm and sulcular incisions (*Figure 2a*/*Figure 3a*) were made in the alveolar mucosa near the base of the vestibule, apical to recipient sites (Chao, 2012). A papilla elevator (*Figure 2b*/*Figure 3b*) was inserted through the entry incision and a full thickness muco-periosteal flap was elevated.

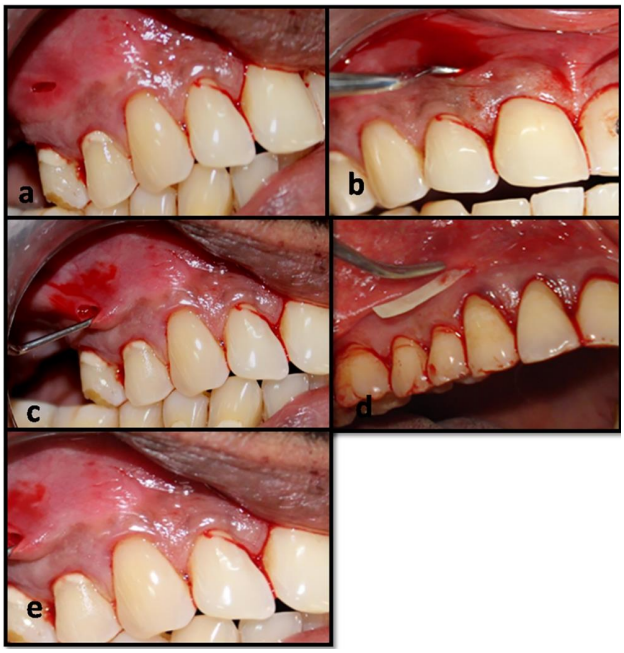

Figure 2. Surgical procedure for MICAT (control group). a) 2-3 mm incision at mucogingival junction; b) Insertion of papilla elevator TKN2 for tunnel preparation; c) Passive tunnel advancement; d) Tucking of bio-resorbable collagen membrane; e) Final position of gingival margin with passive advancement.

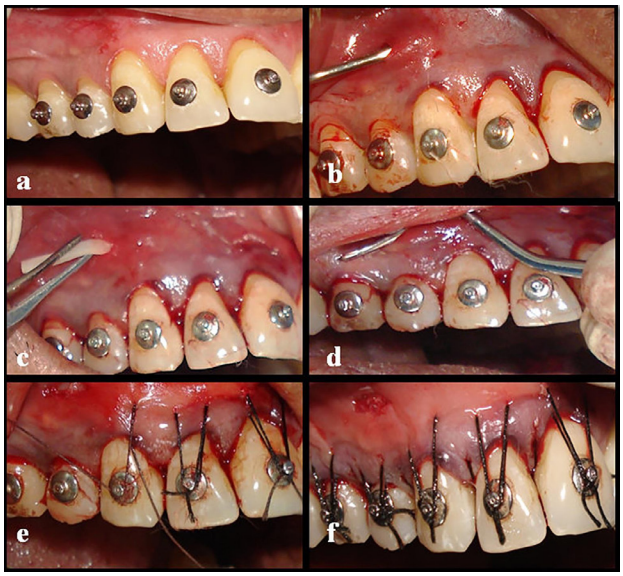

Figure 3. Surgical procedure for MICAT with buttons and sutures (test group). a) Cementation of orthodontic buttons, 2-3mm incision at mucogingival junction; b) Insertion of papilla elevator TKN2 for tunnel preparation; c) Passive tunnel advancement; d) Tucking of bio-resorbable collagen membrane; e and f) Final position of gingival margin with suspensory sutures.

Elevation of flap was guided by tactile perception, visualization and movement of instrument through mucosa and gingival tissue (Chao, 2012). Flap reflection was then extended coronally and horizontally *(Figure 2c/ Figure 3c)* to allow for elevation of two adjacent papillae on each side of the denuded roots (Chao, 2012). The interproximal extension of flap resulted in a freely movable flap, which was then positioned coronally to extend beyond the CEJ. The flap mobilization was considered adequate when the marginal portion of the advanced flap passively reached a level coronal to CEJ by >1 mm, on every tooth in the surgical area (Ozcelik *et al.,* 2011).

Bio-resorbable collagen membrane (Healiguide™, EnColl Corp., USA; Zadeh, 2011) (strips pre-soaked in sterile water) was tucked with curved tissue forceps (*Figure 2d/ Figure 3d)* into sub-gingival spaces under the papillae and marginal soft tissue until the flap was advanced to the desired coronal position (Chao, 2012). In the control group tissue tension created by distension or pouching of the flap with the graft strips held the advanced flap in place (without sutures or tissue adhesives; *Figure 2e*). Gentle digital pressure was applied for 5 minutes approximately (Chao, 2012; Tarnow, 1986). The incision was left to heal by primary intention without suturing (Chao, 2012). In the test group, the surgical procedure of flap reflection was identical to the control group but the flap was advanced about 2 - 3 mm coronal to the CEJ (Ozcelik *et al.,* 2011) and was maintained in this position by suspended sutures around the orthodontic buttons on teeth and around teeth (*Figure 3e* and *Figure 3f*). The sling sutures with 5-0 silk (Mersilk, Ethicon, Johnson & Johnson, Himachal Pradesh, India) were used to suspend the central area of the flaps on the buttons. These sling sutures would allow for the most coronal positioning of the flaps. The second sutures with 6-0 silk (non-absorbable surgical sutures) were performed to accomplish a precise adaptation of the buccal flap on the convexity of the underlying crown surface and permitted the stabilization of every surgical papilla (Ozcelik *et al.,* 2011). Periodontal dressing (Coe Pack – non-eugenol periodontal dressing, GC America Inc. ALSIP, IL, USA) was applied to avoid any mechanical trauma (Ozcelik *et al.,* 2011).

Post-operative instructions

Post-operative instructions consisted of 0.2% chlorhexidine gluconate mouth rinse 3 times daily for 1 minute and avoidance of brushing at surgical site for 6 weeks (Chao, 2012). Post-operative pain and edema was controlled with non-steroidal anti-inflammatory drug (ibuprofen 400 mg t.i.d. for 3 days) and antibiotic (amoxicillin 500 mg t.i.d. for 7 days (if patient was allergic to penicillin then clindamycin 300 mg q.i.d. for 7 days) after meals was prescribed. Patients were advised to consume only soft and warm food during the first week (Ozcelik *et al.,* 2011).

Post-surgical protocol

The sutures, orthodontic buttons and periodontal dressing were removed 14 days after surgery. After this period, patients were reinstructed in mechanical cleaning of the treated teeth and use of a soft toothbrush and roll technique of brushing for 1 month (Zucchelli *et al.,* 2009). Patients were recalled for reinforcement of oral hygiene instructions and light debridement with ultrasonic scalers supra-gingivally 2 and 4 weeks after suture removal and subsequently once every 2 months for 6 months (Zucchelli *et al.,* 2010).

All clinical parameters were re-recorded at 6 weeks, 3 months and 6 months after surgical reconstruction, using a UNC-15 probe in a manner similar to pre-surgical baseline measurements.

Statistical analysis

The SPSS (Statistical Package for Software and Social Science, version 23) method of statistical analysis was used in this study. For each continuous variable, normality was checked by Kolmogorov-Smirnov, Shapiro-Wilk tests and by histograms. If normality assumption was not met then comparisons between the groups were carried out by non-parametric tests. The difference in parameters between different time intervals was assessed by one-way analysis of variance (ANOVA). The intergroup comparison both at baseline and six months was assessed with unpaired Student's *t*-test. Post-operative gingival margin location between the groups was compared using the Mann-Whitney test. The percentage of MRC and CRC between the groups was analyzed using unpaired Student's *t*-test.

Results

All patients included in the clinical trial completed the study. No patient reported any post-operative complications or adverse effects, such as severe edema, pain or sensitivity. Healing was uneventful in all cases.

Patient and defect characteristics

All the included patients were males. The age group ranged from 22 to 55 years. The mean age was 46.12 ± 9.40 years. The split mouth study conducted included a uniform distribution of teeth in both study groups.

The mean recession depth in the control group decreased by 1.89 mm, and by 1.97 mm in the test group, both of which were highly statistically significant ($p < 0.001$; *Tables 1* and *2*). The test group showed a statistically significant ($p < 0.001$) advancement of the gingival margin as compared to the control group (*Table 3*). At 6 months the mean root coverage (%) achieved in the control group was 82.4% and in the test group it was 85.7%, which was statistically similar in both groups. At 6 months follow-up 56% sites in the control group and 73% sites in test group showed complete root coverage; the difference between the two groups was not statistically significant (*Table 3*). In the control group and test group the gingival recession width noted at 6 months was 1.51 ± 1.33 mm and 1.68 ± 1.43 mm, respectively, which was highly statistically significant ($p < 0.001$). However, in comparison the groups were similar. There was no significant increase in the width of keratinized tissue in either the control (*Figure 4a* and *Figure 4b*; $p = 0.95$) or the test group ($p = 0.92$; *Figure 4a*$_1$ and *Figure 4b*$_1$, *Tables 1* and *2*).

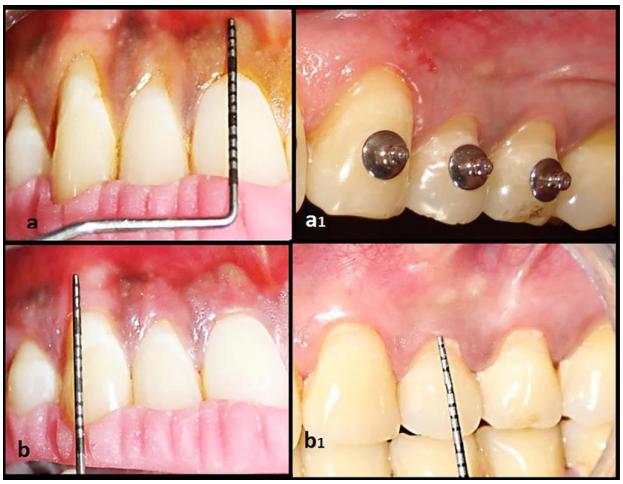

Figure 4. Control group: Comparison between a) pre-operative and b) 6-month post-operative appearance. Test group: Comparison between a$_1$) pre-operative and b$_1$) 6-month post-operative appearance.

Patients reported a satisfactory RES in both the groups. However, aesthetic outcomes at 6 months follow-up showed no statistically significant difference ($p = 0.85$) between the test and control group (RES score = 9.40 ± 1.69 mm and 9.46 ± 1.6 mm, respectively). The probing depth reduction at 6 months was not statistically significant between the two groups. The CAL gain achieved in the control and test groups at 6 months was 1.49 ± 0.68 mm and 1.38 ± 0.66 mm, respectively, which was not statistically significant ($p = 0.593$).

Discussion

Although all perio-plastic treatment techniques have shown potential for root coverage, meta-analysis from several systematic reviews by Roccuzzo *et al.* (2002), Clauser *et al.* (2003) and Cairo *et al.* (2008) reveal an ample degree of variability of clinical results (Ozcelik *et al.,* 2011). When MRTD are present, an approach to address all recession defects at one single surgical visit is the preferred choice (Carvalho *et al.,* 2006). The coronally advanced flap technique alone and with various modifications has been used widely and successfully. But these techniques have long procedural times and high morbidity due to a second surgical site, which has led to the need for a newer minimally invasive, practical, short duration, single site surgery and patient-centered approach in the management of MRTD.

Table 1. Intragroup comparision of gingival recession depth, pocket probing depth (PPD), clinical attachment level (CAL) and keratinized width between baseline, 6 weeks, 3 months and 6 months between MICAT (control group) and MICAT with button and sutures (test group)

	MICAT (Mean ± SD)	95% Confidence interval for mean		MICAT + button + sutures (Mean ± SD)	95% Confidence interval for mean	
		Lower bound	Upper bound		Lower bound	Upper bound
Gingival recession depth (mm)						
Baseline	2.5 ± 1.04	2.12	2.80	2.3 ± 0.9	2.04	2.61
6 weeks	0.6 ± 0.8	0.35	0.88	0.50 ± 0.847	0.23	0.77
3 months	0.5 ± 0.7	0.25	0.75	0.17 ± 0.38	0.04	0.30
6 months	0.6 ± 0.7	0.33	0.80	0.35 ± 0.66	0.14	0.56
p value	< 0.001* S			< 0.001* S		
Difference (baseline - 6 month)	1.9 ± 0.3			1.98 ± 0.22		
p value	< 0.001* S			< 0.001* S		
Keratinized tissue width (mm)						
Baseline	13.3 ± 1.9	12.69	13.98	13.25 ± 2.2	12.54	13.96
6 weeks	13.2 ± 1.7	12.67	13.74	13.03 ± 2.0	12.38	13.67
3 months	13.2 ± 1.7	12.66	13.81	13.06 ± 1.9	12.38	13.73
6 months	13.4 ± 1.8	12.84	13.98	13.28 ± 1.8	12.67	13.88
p value	0.956 NS			0.925 NS		
Difference (baseline - 6 month)	-0.08 ±0.23			-0.03 ± 0.32		
p value	0.998 NS			1.000 NS		
PPD (mm)						
Baseline	1.7 ± 0.5	1.40	1.73	1.65 ± 0.5	1.50	1.80
6 weeks	1.0 ± 0.2	0.98	1.12	1.02 ± 0.2	0.97	1.08
3 months	1.0 ± 0.0	1.00	1.00	1.00 ± 0.001	1.00	1.00
6 months	1.0 ± 0.0	1.00	1.00	1.00 ± 0.001	1.00	1.00
Difference (baseline - 6 month)	0.7 ± 0.5			0.65 ± 0.4		
p value	< 0.001† S			<0 .001† S		
CAL (mm)						
Baseline	3.8 ± 1.08	3.44	4.15	3.83 ± 1.0	3.50	4.15
6 weeks	1.6 ± 0.8	1.36	1.87	1.60 ± 0.8	1.33	1.87
3 months	1.4 ± 0.7	1.21	1.67	1.20 ± 0.4	1.06	1.34
6 months	1.5 ± 0.7	1.27	1.71	1.38 ± 0.7	1.16	1.59
Difference (baseline-6 month)	2.3 ± 0.38			2.45 ± 0.3		
p value	< 0.001† S			< 0.001† S		

*Tukey's post-hoc analysis: $p < 0.001$; †ANOVA: $p < 0.001$; S, significant; NS, not signifi-

Table 2. Intergroup comparison of clinical parameters at baseline and 6 months post-surgery

Parameter (mm, mean ± SD)	Time interval	Control group	Test group	*p* value
Gingival recession depth	baseline	2.46 ± 1.05	2.33 ± 0.89	0.534 NS*
	6 months	0.56 ± 0.72	0.35 ± 0.66	0.172 NS*
Keratinized tissue width	baseline	13.33 ± 1.99	13.25 ± 2.22	0.861 NS*
	6 months	13.41 ± 1.76	13.28 ± 1.89	0.743 NS*
Probing depth	baseline	1.56 ± 0.50	1.65 ± 0.48	0.248*
	6 months	1.00 ± < 0.001	1.00 ± < 0.001	-
Clinical attachment level	baseline	3.79 ± 1.08	3.83 ± 1.01	0.847 NS†
	6 months	1.49 ± 0.68	1.38 ± 0.67	0.593 NS†

*Unpaired Student's *t*-test; †Friedman's test; NS, not significant

Table 3. Post-operative gingival margin location, root coverage percentage and complete root coverage between study groups at 6 months post-operatively.

	Post-operative gingival margin location/Mean advancement (mm)	Mean root coverage percentage (%)	Complete root coverage (%)
MICAT group	0.75 ± 0.82	82.4 ± 21.12%	56.4%
MICAT + buttons and sutures group	1.71 ± 0.83	85.7 ± 27.31%	72.5%
p value	0.001* S	0.539 NS‡	0.135 NS‡

*Mann-Whitney test; ‡Unpaired Student's *t*-test; S, statistically significant; NS, not significant

The success of any root coverage procedure largely depends on its capability of maintaining the position of the GM reached at the end of surgery. The importance of advanced flap stabilization has been demonstrated, with superior results reported when flap anchorage was obtained by suturing (Marggraf, 1985; Romanos *et al.,* 1993) or placement of surgical adhesive or composite stops (Bittencourt *et al.,* 2006; Bittencourt *et al.,* 2007; Aroca *et al.,* 2010) as compared to the original technique by Tarnow (1986). It has also been shown that the greater post-operative displacement of gingival margin and minimal flap tension may favor high root coverage and an aesthetic clinical outcome (de Sanctis and Clementini, 2014; Zabalegui *et al.,* 1999).

Interrupted and suspensory sutures are the most commonly used suturing techniques reported in the literature for both laterally and coronally moved flaps (Bernimoulin *et al.,* 1975; Allen and Miller, 1989). Similarly, when an envelope approach is used, the sutures stabilize the buccal flap, and the surgical papilla. It also allows for a precise adaptation of the buccal flap over the exposed root surface and stabilizes every single surgical papilla over the interdental connective tissue bed (Zucchelli and De Sanctis, 2000; Zucchelli *et al.,* 2004; Zucchelli and De Sanctis, 2007).

It has been demonstrated that the position of the gingival margin in relation to the CEJ at the end of surgery is an important factor in achieving CRC (Pini Prato *et al.,* 2005). The majority of authors suggest that locating the gingival margin 1 mm (Zucchelli and De Sanctis, 2000; Zucchelli *et al.,* 2004; de Sanctis and Zucchelli, 2007) or 2 mm (Pini-Prato *et al.,* 1999; Pini Prato *et al.,* 2005) coronal to the CEJ is essential to compensate for post-surgical soft tissue shrinkage.

To prevent tissue collapse, Aroca *et al.* (2010) included composite stops and Ozcelik *et al.* (2011) used orthodontic buttons. Results of such techniques lead to a statistically significant recession reduction compared to the CAF alone. Horizontal mattress sutures used to anchor the coronally repositioned papillary mucoperiosteal flap unit to the interdental contact point during root coverage and papillary construction procedure resulted in enhanced periodontal esthetics (Azzi *et al.,* 2001). The PST™ described by Chao (2012) does not employ any suturing technique and depends entirely on the packing of the CM in the tunnel to advance and hold the advanced tunnel at the desired position. The stabilization for the first 2 weeks after coronal advancement is very critical in accentuating the treatment outcomes. The lack of sutures may lead to tissue retraction and hamper the long-term outcomes. Hence, in order to stabilize the advanced position of the GM, suspended sutures have been investigated in addition to the surgical technique. The intent of the clinical trial is to evaluate the added advantage, if any, of the suspended sutures with orthodontic buttons in combination with the surgical technique for root coverage of MRTD.

In the current trial, GM advancement coronal to CEJ of 1.71 ± 0.83 mm was observed in the test sites, which was statistically significant, and MRC of 85.7% and CRC of 72.5% was noted. This was similar to the GM post-operative advancement of 1.7 ± 1.3 mm achieved by Ozcelik *et al.* (2011), who reported MRC of 96.2%. The mean advancement achieved in the control group was 0.74 ± 0.82 mm, and the inter-group comparison of GM location was statistically significant ($p < 0.005$), with higher coronal advancement of the flap in the test sites as compared to the control sites. It is noteworthy that only 56.4% of sites achieved CRC in the control sites, whereas 72.5% sites achieved CRC in the test group. Greater post-operative coronal displacement of the flap beyond the CEJ in the test group as compared to control group was associated with greater probability of achieving CRC, as also noted by Pini Prato (2005). Because of the significantly lesser GM advancement noted in the control group we can presume that this technique may have less than favorable outcomes in deep recessions.

Statistically significant MRC (85.7%) and CRC (72.5%) were achieved in the test group. MRC of 82.4% and CRC of 56.4% was noted in the control group at the end of 6 months. The outcomes in the control group were comparable to the results of Chao *et al.* (2012), i.e., CRC 81% and CRC 94%. Similar results were also reported by Ozcelik *et al.* (2011), i.e., MRC 96.2% in the test sites with orthodontic buttons was achieved in comparison to 89.1% recession coverage in the control group.

The outcomes are also similar to those of Aroca *et al.* (2010); the MRC was 82% and CRC (38%). The use of composite stops in the study aided in the advanced GM location post-surgically. Similarly, in the current trial, the suspensory sutures stabilized on orthodontic buttons led to an increase in the coronal advancement of GM. CAF with vertical releasing incisions have shown 77.7% of CRC and 92.5% of MRC, whereas MCAF has reported 89.3% of CRC and 97.2% of MRC. In the current trial the tunnel approach eliminates papillary incision, thus favoring better vascularization. However, this tunnel approach did not show any added advantage over CAF and MCAF (Zucchelli *et al.,* 2009). The outcome of the treatment of multiple gingival recessions is dependent on various factors and not only on the design of the surgical technique. Soft tissue substitutes such as porcine collagen matrices (Aroca *et al.,* 2013), platelet-rich fibrin (Aroca *et al.,* 2009) and acellular dermal matrix (Gapski *et al.,* 2005) have yielded either similar or lower CRC when compared to CTG. A significant reduction of recession depth was noted in both groups at 3 months and 6 months follow-up. However, there was a slight increase in the recession depth from the third month to the sixth month. This can be attributed to the soft tissue shrinkage that follows the maturation of the collagen apparatus in the healing wounds.

The root coverage esthetic score was proposed by Cairo *et al.* (2009) to evaluate the aesthetic outcome following root coverage surgeries and has been used widely. In the present clinical trial RES in both the test and control groups was recorded by a calibrated examiner. The scores were good and comparable to each other: 9.38/10 and 9.46/10 respectively. A favorable aesthetic outcome is achieved when tunnel procedures are carried out when compared to CAF (Aroca *et al.,* 2010).

The mean differences in apico-coronal width of keratinized tissue were 0.077 mm in the control group and 0.025 mm in the test group between baseline and 6 months, which were not statistically significant. Similarly, Ozcelik *et al.* (2011) also reported 0.48 mm increase in keratinized tissue and Aroca *et al.* (2010) reported a 0.2 mm gain, which were both in accordance with our results. On the contrary, Chao (2012) reported 1.3 mm gain in keratinized tissue width. A mean of 0.37 ± 0.5 mm of keratinized tissue width gain was noted by Pini-Prato *et al.* (2005). In a similar study Pini-Prato *et al.* (1999) noticed a reduction in the keratinized tissue width that was explained by explorative statistical analysis that the post-surgical apical shift of the gingival margin was related to the immediate post-surgical GM position coronal to the CEJ. Reductions in keratinized tissue width of 0.37 mm (Pini-Prato *et al.,* 2005) and 0.4 mm (Pini-Prato *et al.,* 1999) were attributed to the GM position at the time of suturing. The lack of significant gain in keratinized tissue width may be explained by the reduction in blood supply (due to surgical incision) to the marginal gingiva during the early phase of wound healing (Baldi *et al.,* 1999; Pini-Prato *et al.,* 2000; Zucchelli and de Sanctis, 2005; de Sanctis and Zucchelli, 2007). As observed in previous studies, an increase in keratinized tissue width is a phenomenon observed over a longer follow-up period, as it is related to creeping attachment and gradual movement of the MGJ towards its genetically determined location. Thus the difference in keratinized tissue width may not be appreciated in a 6-month short-term trial (Ainamo *et al.,* 1982; Zucchelli *et al.,* 2009). This change in keratinized tissue width may be technique-dependent (Cairo *et al.,* 2008). A smaller keratinized tissue width increase was found with a CAF when compared with an envelope flap (Cordioli *et al.*, 2001). As this is a short-term assessment of the efficacy of the surgical procedure, and as the length of follow-up is a positive predictive factor in terms of aesthetics, a follow-up period of >12 months would be more conclusive (Kerner *et al.,* 2008; Ozcelik *et al.,* 2011).

The overall PD reduction achieved at 6 months was 1 mm for both test and control study groups, which was statistically highly significant ($p < 0.001$). The CAL gain in the present trial was 2.3 mm in the control group and 2.45 mm in the test group, which were both statistically significant at different time intervals (6 weeks, 3 months and 6 months). Aroca *et al.* (2010) reported a CAL gain of 2.86 mm. The reduction in plaque and improvement of the gingival index was statistically significant ($p < 0.001$) in both groups. The 6-month follow-up period was chosen in this present study because this period is considered adequate to provide soft tissue maturity and stability, as reported in systematic reviews (Cairo *et al.,* 2008, Rosetti *et al.,* 2000).

The MICAT is quite predictable for root coverage of multiple defects and, in many cases, provides full root coverage. In this technique the envelope flap was carefully released beyond the muco-gingival line by a papilla elevator and tunneling instrument to obtain an effect similar to that of a horizontal releasing incision in the advanced flap technique and is similar to the tunneling procedures (Allen and Miller, 1989; Zabalegui *et al.,* 1999; Aroca *et al.*, 2010). The GM position at the end of this surgery is governed by various factors such as the number, height and width of gingival recessions, interdental attachment level, amount and thickness of keratinized tissue, and vestibular depth and size (De Sanctis and Clementini, 2014). The final position of the GM at the end of the surgery has a critical bearing in the final outcome. (Pini-Prato *et al.,* 2005).

The use of suspended sutures around the orthodontic buttons provided good coronal stabilization of the flap during the first 2 weeks of the crucial wound healing period, as compared to the control group. 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.,* 2010) and increased complete root coverage was found when advancing the flap over the CEJ (Pini Prato *et al.,* 2005).

Both surgical techniques resulted in highly aesthetic and significant mean root coverage independently. However, there was a lack of statistical significance between the groups in the clinical trial. In conclusion, the results of this study indicate that both treatment options resulted in similar, consistent reduction in recession depth.

The importance of the mucosal incision is also very critical and justified. This incision greatly aids in the entry of a tunnelling instrument that can be manoeuvred with great ease in the MGJ area. In deep recessions (> 5 mm) with anatomic deviations it helps in easy dissection of collagen fibres in the apical area. The incision reduces the chances of collapse of the advancing tunnel. This incision heals by primary intention and requires no separate surgical sutures, and therefore no scar will form.

When this apical entry is not made, reaching the MGJ during tunneling procedures via the coronal/sulcular incisions is very technique-sensitive, and the control and tactile stability is poor. Moreover, the collagen fiber dissection is compromised and cannot be evaluated precisely through the blind tunnel, which can compromise the aesthetic outcome. Hence, this 2 - 3 mm horizontal mucosal incision is very beneficial and provides tactile stability and an easy surgical approach.

One of the limitations is the use of thin strips of collagen membrane, as it is not only cumbersome but the tucking of these collagen strips was time consuming. A collagen membrane, acellular dermal matrix or collagen matrix of the entire dimension would be better suited for tucking in the pouch, as it would require not only less time but even provide a better tactile control in the blind tunnel, as positioning the cut thin strips was very technique-sensitive and a lot of difficulty was encountered to position them in the recession and interdental areas under the papilla. Slipping of these strips through the sulcus was also noted. In the authors' opinion, the need for such a maneuver may be replaced with a single strip of soft tissue/soft tissue substitute.

The application of orthodontic buttons prior to surgery was time consuming and the specialized suturing technique used to anchor the advanced flap to the orthodontic buttons requires surgical skill and extra time. However, in the current trial this modification did not show any added advantage. This can also be easily substituted with composite stops in the interdental area, which will be less time consuming and more economical.

The use of specially designed papilla elevators in the original PST technique (Chao, 2012) was easily substituted by the TKN2 papilla elevators (TKN2, Hu Friedy, Chicago, IL, US) effectively in the current study.

Another limitation of this trial is that, as this is a short-term assessment of the efficacy of a technical procedure, the evaluation period used in this study was 6 months from the last surgical treatment. Although this period is considered adequate (Roccuzzo *et al.,* 2002; Cairo *et al.,* 2008), the length of follow-up is a positive predictive factor in terms of aesthetics and the follow-up period should not be <12 months (Kerner *et al.,* 2009). Therefore, a longer period of evaluation is probably necessary to assess whether these initial positive results are modified with time.

The use of MICAT is a minimally invasive, predictable, cost-effective, less time consuming method for achieving optimal patient-based outcomes in root coverage procedures. Satisfactory healing with no deleterious effects or post-operative complications was observed after both surgical techniques. Currently the preferred way of performing perio-plastic surgery is with the use of microsurgical instruments and magnifying aids. However in the current trial this approach was not followed and might have provided better outcomes if incorporated (Burkhardt and Lang, 2014).

The root coverage obtained highly improved the aesthetics and met the expectations of the patients. Within its limitations, the present randomized prospective clinical trial showed satisfactory healing outcomes and predictable root coverage, and highly aesthetic results with favorable patient compliance. Further, there is a need for long-term randomized controlled clinical trials comparing the MICAT technique with commonly advocated surgeries (CAF + CTG) for root coverage in MRTD. Randomized clinical trials assessing the long-term outcomes (5 years) are encouraged. There is also a need for more studies assessing the benefits of the advanced gingival margin location beyond CEJ and its long-term stability involved in perio-plastic surgeries for MRTD coverage.

Future perspective

Hence, randomized controlled clinical trials with a longer follow-up time period and a larger sample size need to be undertaken to further strengthen the concept of gingival margin advancement beyond CEJ by using suspensory sutures on anchoring units in root coverage procedures which are minimally invasive, predictable, cost- and time-effective to achieve aesthetic surgical outcomes. The incorporation of soft tissue substitutes/CTG in the entire dimension should be compared with the outcomes of the original technique. Further randomized controlled studies that assess CAF + CTG versus the current protocol should be evaluated.

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