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ORIGINAL ARTICLE

Effect of connective tissue graft orientation on the root coverage outcomes of coronally advanced flap

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Abstract The aim of the present study was the evaluation of the effect of connective tissue graft orientation on clinical outcome of root coverage procedure when applied in conjunction with coronally advanced flap. Sixteen similar bilateral recession defects—Miller's class I and II—in eight patients were treated using coronally advanced flap and connective tissue graft harvested from the palate. The defects in each patient were randomly allocated to P-teeth or P-flap groups with the periosteum contacting the tooth surface or the flap, respectively. After initial scaling and root planing, acrylic templates of the treatment sites were generated. Recession depth (RD), recession width (RW), gingival sulcular depth, clinical attachment level, length of keratinized tissue, papilla width, and percentage of root coverage were measured at baseline, 1 and 3 months postoperatively. Wilcoxon and Mann–Whitney *U* tests were used for analyzing the data. The reduction in RD averaged 3.68 mm in P-teeth and 3.25 mm in P-flap. RW decreased 2.68 and 2.6 mm in P-teeth and P-flap, respectively. Keratinized tissue increased an average of 1.25 mm in P-teeth and 1.31 mm in P-flap. Clinical attachment gain equaled 3.87 mm for P-teeth and 3.32 mm for P-flap. All variables exhibited significant improvement compared to baseline ($P<0.0001$), but between-group differences were negligible ($P>0.05$). It could be concluded that while the application of connective tissue graft with coronally advanced flap is efficient for coverage of Miller's class I and II gingival recession defects, the short-term clinical outcome of this surgical method is not affected by orientation of connective tissue graft.

Keywords Gingival recession · Coronally advanced flap · Connective tissue graft · Periosteum

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Introduction

Gingival recession or marginal tissue recession is the apical movement of the gingiva [43] or the alveolar mucosa [27]—where gingival tissue does not exist—exposing the root surface. The surgical coverage of denuded root surfaces is purported to meet the esthetic concerns as well as the functional demands of the dental patients such as the amelioration of dentinal hypersensitivity or the management of mucogingival problems. Pedicle grafts [36], free gingival grafts or autogenous masticatory grafts [37], guided tissue regeneration [33], and subepithelial connective tissue grafts with and without acellular dermal matrix (Alloderm) [23] are the most commonly used surgical approaches in the contemporary dental practice. The most efficient root coverage method is the subepithelial connective tissue graft [42]. The amount of root coverage using this technique

approximates 52–98%, and the complete root coverage has been achieved in 20–89% of cases [42].

Goldstein et al. [13] treated a case of gingival recession using a connective tissue graft along with the associated periosteum. The subsequent histological evaluation after 14 months revealed the formation of a connective tissue new attachment, cementum, and periodontal fibers throughout a region corresponding to the location of the graft. The clinical attachment gain was 3.9 mm in the aforementioned study. However, the use of connective tissue graft without the periosteum resulted in the formation of long junctional epithelium except a few points in the apical region where a cementum-like tissue was found [26]. It has been suggested that the connective tissue without the periosteum is unable to form bone and cementum [14, 16].

Al-Zahrani et al. [3] evaluated the influence of connective tissue graft orientation on coverage of denuded root surfaces. While the external surface of the graft was in contact with the root surface in one group, it contacted the gingival flap in the other group. The evaluation of the results after 3 months did not show any differences between the groups with reference to the amount of root coverage or gingival augmentation. However, the aforementioned study used a graft lacking in anatomical and biological polarity; it did not include the surface epithelium or the underlying periosteum. The aim of the present study was to investigate the effect of orientation of a polarized graft comprising the connective tissue and the underlying periosteum on the coverage of gingival recession defects.

Materials and methods

Study population

A total of eight patients with a mean age of 35 years participated in the present randomized controlled clinical trial. The patients presented with a chief complaint of poor esthetics or dentine hypersensitivity. Sixteen similar bilateral buccal recession defects (maximal difference in recession depth [RD]=0.5 mm) in the visible anterior segment of jaws were selected. The recessed sites were associated with the teeth in the same class trait. Only Miller's class I and II recession defects with similar size and morphology and at least 1 mm of keratinized gingiva were selected. Patients with a history of smoking, alcohol consumption, and debilitating systemic diseases affecting the periodontium or wound healing were excluded. The selected teeth were caries-free, without restoration, and had a vital pulp as determined by electrical and thermal stimulation.

The information regarding the study and the surgical procedures were explained to the patients, and all of them signed a written consent form. This study was approved by the ethical and the research committees of the Tabriz University of Medical Sciences.

Presurgical procedures

All the patients received oral hygiene instructions before the initiation of the study. They entered a preliminary phase consisting of nonsurgical plaque removal. Afterward, during four follow-up sessions at intervals of 1 week, the probing depth, plaque index (PI), and gingival index (GI) of the experimental sites were monitored closely, and toward the end of these sessions, GI and PI of the selected experimental sites were equal to/less than 1. After this preliminary phase, impressions of the affected sites were taken, and translucent acrylic templates with guiding fissures, to assure reproducibility of measurements, were constructed. Measurements were performed with a standard William's periodontal probe using the guiding fissures (Fig. 1). The following parameters were recorded for the subjects at baseline, 1 and 3 months postoperatively: RD, recession width (RW), gingival sulcular depth (GSD), clinical attachment level (CAL), length of keratinized tissue (LKT), and papilla width (PW). RD was assessed as the length of the line, passing through the most apical extent of the soft tissue margin at the recession site perpendicularly and connecting it to the cementoenamel junction (CEJ) at a rather vertical path. RW was measured as the length of a line connecting the two points at the most coronal parts of the recession. PW was measured through an imaginary line between the CEJ of the recessed site and the CEJ of the adjacent tooth. Percentage of root coverage (PRC) was measured after 1 and 3 months postoperatively.

Surgical procedures

In each patient, the selected teeth were randomly assigned to experimental groups. A code was allotted to each tooth, which was blind to the surgeon and also the examiner. After

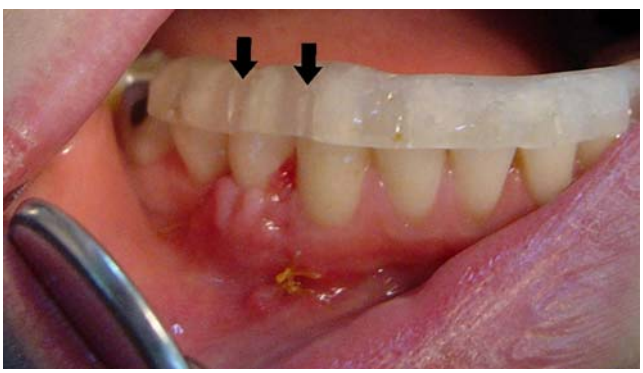

Fig. 1 Acrylic template and the guiding fissures (*black arrows*)

local infiltration anesthesia (Xylocaine® 2%, epinephrine 1/100,000, Dentsply), tetracycline was applied to the denuded root surfaces. A 250-mg capsule of tetracycline (Ambramicina®, Scharper) was dissolved in 2 ml of sterile 0.9% NaCl solution, and sterile cotton pellets were used to rub it to the area for 2 min. These pellets were changed every 30 s. Finally, the area was rinsed thoroughly with normal saline.

A horizontal incision, 0.5 mm cervical to the gingival margin of the adjacent teeth, was initiated and continued as a sulcular incision in the recessed site. Two vertical incisions at both mesial and distal sides of the horizontal incision were made past the mucogingival line. The mucoperiosteal flap (Mean thickness=1.1 mm) was separated using a periosteal elevator. The thickness of the flap and connective tissue graft was measured using a gauge. The surface epithelium of the interdental papillae adjacent to the recessed site was removed by a round bur.

The palatal mucosa between the canine and the mesial line angle of the maxillary first molar was used as the source of the periosteal connective tissue. A primary horizontal incision was made according to the mesiodistal width of the recession site and at a distance of 2 mm from the gingival margin. A vertical incision of 5 mm from the mesial end of the horizontal incision was performed toward the midline. After separating the assembly of the superficial epithelium and 1 mm of the underlying connective tissue, the periosteal connective tissue (Mean thickness=0.9 mm) was prepared from the remaining tissue, consisting of connective tissue and the periosteum, underneath (Fig. 2). The access flap was returned coronal to its original site (1 mm coronal to CEJ)—using a periosteal releasing incision—and sutured (4–0 silk) to heal by primary intention. The harvested graft was trimmed to adapt to the shape of the recipient site. It was placed on the denuded root surface being limited to the CEJ coronally (Fig. 3). While in the P-teeth group, the periosteum was in contact with the root surface; it was adjacent to the gingival flap in the P-flap group. Using interrupted and sling sutures, the flap and the graft were immobilized and fixed. Both the donor and the recipient sites were covered with a tin foil and the periodontal pack (Coe-Pak®, GC America).

Postsurgical procedures

Postsurgical pain management was accomplished using Ibuprofen (400 mg, pro re nata [prn], Advil®, Wyeth Consumer Healthcare) in painful situations. Furthermore, amoxicillin (500 mg, Amoxil®, GlaxoSmithKline, ter in die for 7 days) was used to prevent postsurgical infection and chlorhexidine mouth rinse (0.2% for 10 days) for the reduction in bacterial colonization and the accumulation of bacterial plaque. After 6 days, the tin foil and periodontal pack were removed, and 3 days later (at the tenth day), the sutures were removed. The patients were advised to start toothbrushing after cessation of chlorhexidine use except for surgical sites, which were gently rubbed using slight

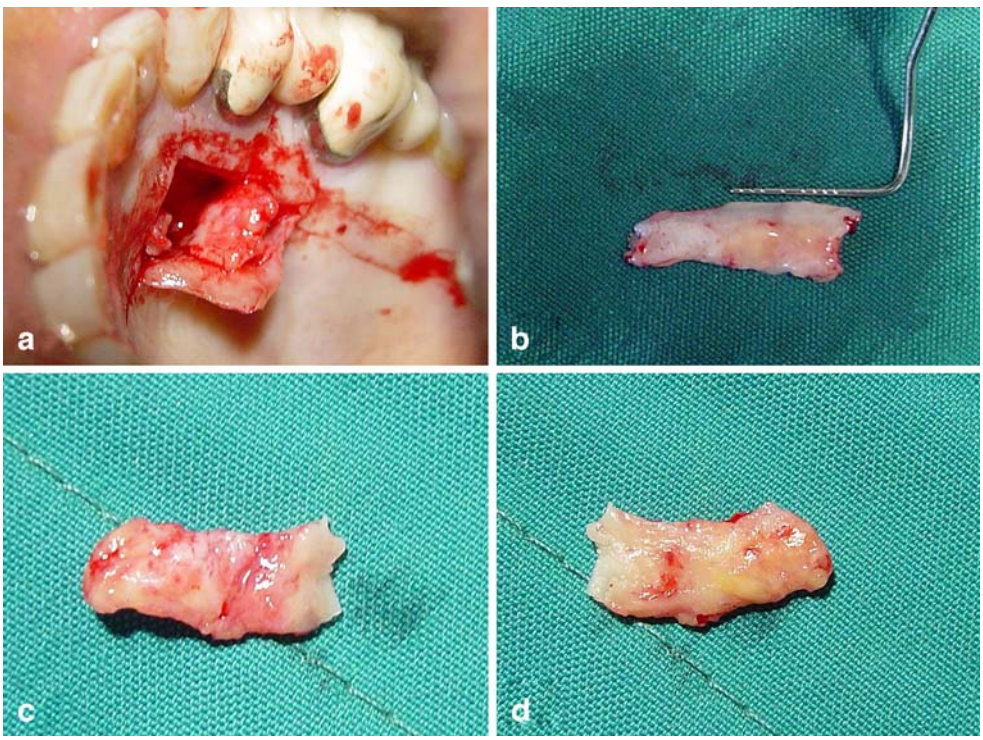

Fig. 2 Preparation of connective tissue graft from palate (**a**, **b**). Superficial connective tissue (**c**) and the underlying periosteum (**d**) are evident

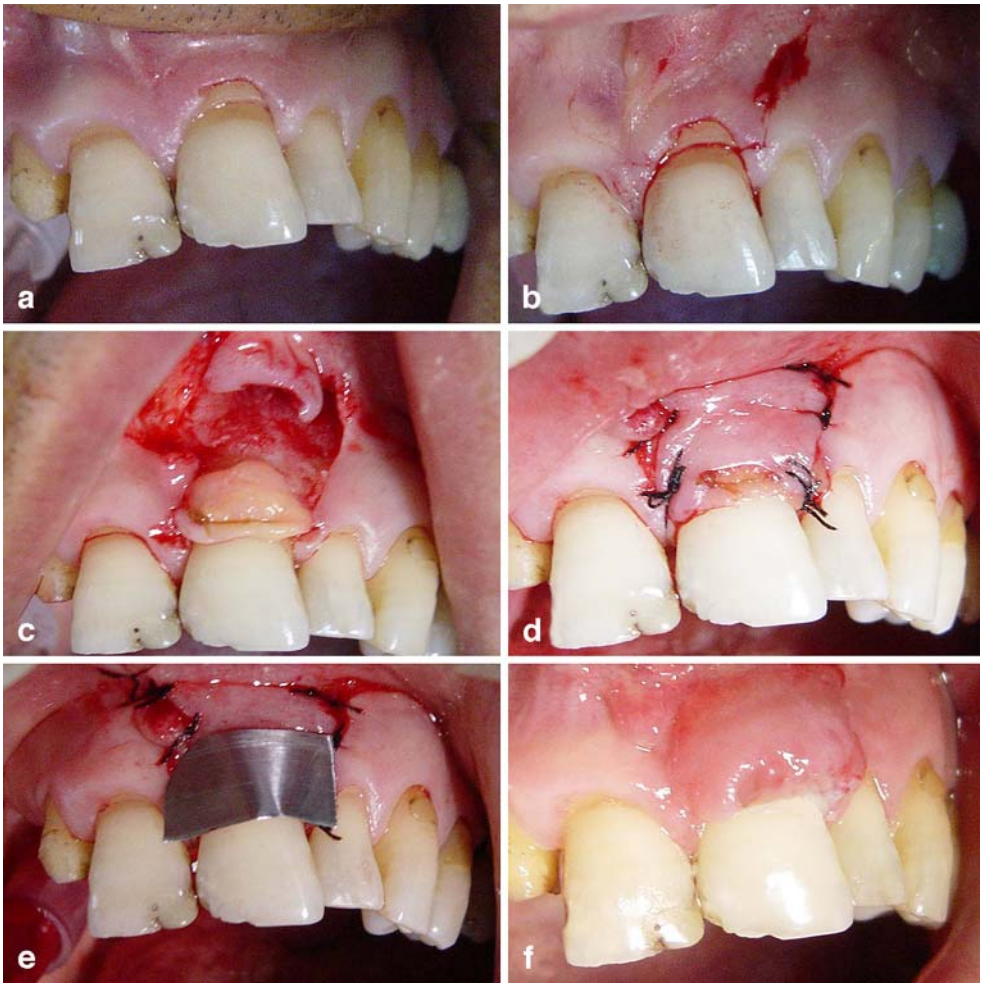

Fig. 3 Initial presentation of gingival recession (**a**). After accomplishment of horizontal and vertical incisions (**b**), the flap is reflected, and the graft is placed on the root surface (**c**) and subsequently sutured (**d**). A tin foil is placed (**e**). Three-month postoperative presentation of recessed site (**f**)

inward pressure with fingers on cheek. Three week after surgery, brushing of surgical sites was started. Follow-up sessions were scheduled for 1 and 3 months postoperatively. During these sessions, professional mechanical tooth cleaning was performed for the patients. Furthermore, the soft tissue parameters were recorded 1 and 3 months postoperatively similar to baseline measurements. The psychological patient-centered assessment of operation was accomplished through a questionnaire about the outcomes of the surgery.

Statistical analysis

The variables are presented as mean±standard deviation. The between-group differences, before and after the treatment, were compared based on the Wilcoxon test. The Mann–Whitney *U* test was used for the comparison of the within-group differences at baseline and 1 and 3 months postoperatively. In the present study, $P<0.05$ was considered to indicate statistical significance.

Results

Sixteen bilateral class I and II gingival recession defects (Miller's classification) in eight patients were included in the present study.

The average changes from baseline to the third month for the studied variables are presented in Fig. 4. The mean RD in P-teeth and P-flap at the baseline equaled 4.46 (SD 0.48) and 4.56 mm (SD 0.56), respectively. This parameter reduced to 0.78 mm (SD 0.99) in P-teeth ($P=0.001$) and 1.31 mm (SD 1.16) in P-flap ($P=0.001$) after 3 months. However, there were not any significant differences between groups regarding the reduction in RD both at first and third months postoperatively ($P>0.05$). P-teeth and P-flap demonstrated an initial RW of 3.00 (SD 0.65) and 3.06 mm (SD 0.49), respectively. The baseline values did not show any statistical differences ($P>0.05$). The initial RW diminished to 0.31 mm (SD 0.37) in P-teeth and 0.43 mm (SD 0.41) in P-flap after 3 months. Despite substantial improvement of within-group values for RW

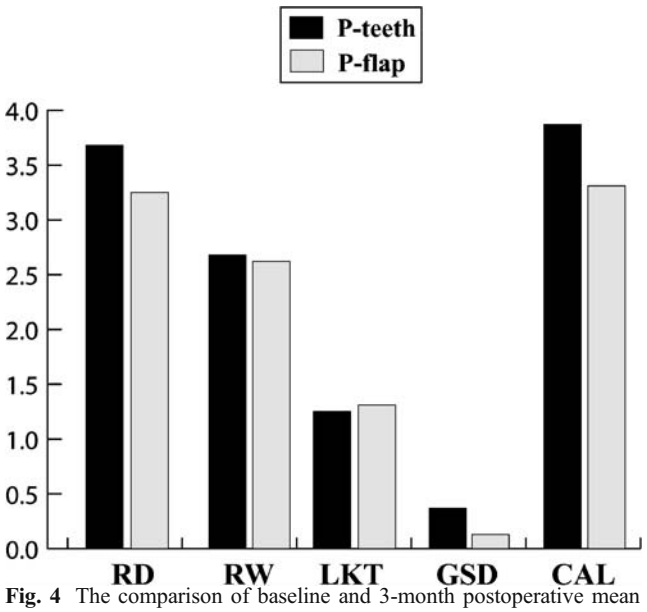

Fig. 4 The comparison of baseline and 3-month postoperative mean values of the studied variables in P-teeth (n=8) and P-flap (n=8) groups

(P<0.000), there were not any significant differences between groups (P>0.05).

The primary LKT in P-teeth was 1.37 mm (SD 0.53) and averaged 2.62 mm (SD 0.64) after 3 months (P= 0.0032). In P-flap, the initial LKT of 1.25 mm (SD 0.49) increased to 2.56 mm (SD 0.56; P=0.0024). No difference was found between the results of these two groups after 3 months (P>0.05).

GSD in P-teeth at the baseline was 0.93 mm (SD 0.43) and averaged 0.56 mm (SD 0.41) at the third month postoperatively (P=0.17). In P-flap, the mean GSD decreased from 0.81 (SD 0.37) to 0.68 mm (SD 0.37; P=0.598). Furthermore, the difference between the two experimental groups did not reach statistical difference (P=0.662). The primary CAL in P-teeth and P-flap equaled 5.31 (SD 0.65) and 5.28 mm (SD 0.70), respectively. This parameter showed an enhancement of 73% in P-teeth and decreased to 1.43 (SD 1.20; P= 0.0086) after 3 months. In P-flap, the improvement of CAL was 62%; it reduced to 2.00 mm (SD 1.41; P= 0.012). Nonetheless, the between-group difference did not reach statistical difference (P=0.38).

While the PRC averaged 81.77% in P-teeth, it was 72.39% for P-flap. This relative superiority of the P-flap to P-teeth with reference to the PRC values does not translate into any statistical significance (P=0.418). The complete root coverage was achieved in 50% of the cases in P-teeth and in 37.5% of the cases in P-flap at the second follow-up. The rest of the operated sites demonstrated 55–75% root coverage in P-flap. In P-teeth, PRC was 50–70% for the remaining cases except for one case with coverage of less then 50%.

The width of papilla in cases was more than 3 mm, and consequently, the variation of this parameter did not have an impact on the amount of root coverage. The thickness of gingival flap in most of the operation sites was more than 1 mm (mean thickness=1.1 mm). In two bilateral cases, the thickness of flap was less than 1 mm. The amount of PRC at the aforementioned operation sites was 55.56 and 40% after 3 months. The thickness of the connective tissue graft averaged 0.9 mm.

Only one of the patients exhibited delayed postoperative bleeding of the donor/recipient sites. Furthermore, the pain and discomfort after the surgery were effectively managed through the use of ibuprofen (400 mg, prn, Advil®, Wyeth Consumer Healthcare).

The psychological patient-centered assessment of the operation was accomplished through questioning about the outcomes of the surgery. The esthetic concerns of the patients were met in cases that showed a PRC above 70%. The same patients believed that the amount of root coverage achieved through surgery is adequate. However, the postsurgical satisfaction of the patients diminished parallel with the decrease in the amount of root coverage. The gradual reduction in the satisfaction, when PRC declined to 60%, was followed by a sudden and remarkable dissatisfaction in PRCs below 60%. These patients did not agree to undergo a second operation and preferred to wait and see the conclusive long-term result of the operation.

Discussion

The aim of the present study was to investigate the effect of the orientation of a polarized graft comprising the connective tissue and the underlying periosteum on the coverage of gingival recession defects. It was found that the orientation of the graft with reference to the periosteum does not affect the clinical outcome of the root coverage procedure.

The reduction in extraneous variables acting as confounding factors was performed to increase the internal validity of the results of the present study. However, because of a lower number of cases in the experimental groups, which could affect the results of statistical analyses, further studies are necessary to support out findings.

Regarding the higher velocity of epithelial repair compared to connective tissue, provision of an anatomical or biological barrier for preventing the invaginating proliferation of epithelium down the CEJ—so-called guided tissue regeneration or GTR—is desirable. This barrier could be either an artificial or natural membrane. The connective tissue graft with the associated periosteum serves as a natural autogenous GTR membrane [30]. This periosteal

graft has been used for the treatment of intrabony defects [22], furcation involvement [24], and gingival recession. Higher resistance and viability of subepithelial connective tissue grafts under ischemic conditions renders it suitable even for wide recession defects with compromised blood supply postoperatively [37].

In the present study, the reduction in RD in P-teeth was 0.43 mm more than that in P-flap (P=0.35). Zucchelli et al. [45] reported a 3.4-mm (SD 0.71) reduction in RD after 1 year using a bilaminar technique. In another study, RD diminished an average of 3.68 mm (SD 1.01) after 12 weeks using a combination of subepithelial connective tissue graft and coronally advanced flap (CAF) [18]. However, in both studies, the initial depth of recession was less than the present study. Huang et al. [20] demonstrated that the amount of RD reduction is positively correlated to the initial RD in the CAF approach.

Root coverage averaged 81.77% (SD 20.33) in P-teeth and 72.39% (SD 24.50) in P-flap after 3 months. These findings are in line with the results of some of the previous studies in which mean root coverage was reported to be 79.3 [7], 81 [39], and 84.3% [8] after 6 months and 85.23% after 5 years [31]. On the contrary, using the same surgical approach, the amount of root coverage equaled 96.2 [17] and 97.1% after 3 months [19] and 94.7 [45], 98.4 [19], and 93.5% [44] in other studies. This relative discrepancy may partially reflect the difference in study design with reference to the follow-up intervals and study duration and also the statistical handling of data.

RW decreased an average of 2.68 mm (SD 0.59) in P-teeth and 2.62 mm (SD 0.64) in P-flap. Wang et al. [40] detected a reduction of 2.7 mm (SD 1.2) in RW after 6 months. In another study by Muller et al. [28], the amount of RW reduction was 35% after 1 year. Harris et al. [18] found that RW reduced from 3.5 (SD 1) to 0.7 mm (SD 1.2) after 3 months and from 3.6 (SD 1.2) to 0.4 mm (SD 1) after 1 year.

The thickness of the flap in all defects was more than 1 mm in all cases except two bilateral case in which flap thickness equaled 0.84 mm leading to a coverage of 55.56 and 40% after 3 months. In pedicled flaps, there is positive correlation between flap thickness and RD reduction [4]. It has been suggested that complete root coverage in Miller's class I and II defects is achieved in flaps having a minimum thickness of 0.8 mm regardless of having full or partial thickness [11]. However, in agreement with our findings, Miller and Allen [2] underscored the importance of a minimal thickness of 1 mm for obtaining the desired clinical outcome in CAFs.

Flap tension is one of the factors affecting the success of CAF. Pini Prato et al. [34] showed that while in areas with 6.5 g of flap tension, mean root coverage and complete root coverage equals 78 and 18%, respectively, the elimination of tension resulted in mean coverage of 87%, and complete coverage was achieved in 45% of cases. The best outcome follows passive placement of the flap [2, 34]. In the present study, after coronal displacement of the flap, the tension was avoided through extension of the vertical incision, and the flap was sutured in its new position with minimal downward mechanical stress.

Dimensions of interdental papilla do not affect the prognosis of the root coverage procedure [35]. The width of the interdental papilla in all cases of the present study exceeded 3 mm without any significant impact on the final outcome. However, primary RD surmounting 5 mm would substantially compromise the result of the coverage procedure [18]. In our study, one case in each group showed an RD of 5.5 mm. It is interesting to note that in both cases, mean root coverage equaled 63.64% being lower than the average value of root coverage, which is in line with the findings of Harris [18].

Bridging and creeping attachment are the key procedures involved in the surgical coverage of denuded root surfaces [6, 35]. Borghetti and Gardella [6] suggested that any increment in the amount of root coverage achieved after 1 month postoperatively may be attributed to the creeping attachment. The amount of creeping attachment in various studies was 0.89 [5, 6], 0.74 [12], and 0.43 mm [41]. We observed an average of 0.12 mm creeping attachment between the first and the third months.

The LKT in P-flap and P-teeth increased an average of 1.31 and 1.25 mm, respectively. In a similar study, the LKT was 2±1.5 mm initially and after 1.5 years reached to 2.7± 1.6 mm [9]. Although the exact mechanism underlying this enhancement is not fully understood, two different scenarios have been proposed. Periodontal wound healing advances through an intermediate stage involving the formation of a scaffold consisting of granulation tissue. The involvement of this tissue in the induction of the keratinization process has been proposed [21, 25, 29]. The granulation tissue harbors a cellular/extracellular composite capable of stimulating keratinization of the adjacent superficial layers. The second proposed mechanism is the rebound of the mucogingival junction to its original position after coronal displacement of the flap [1]. Furthermore, it is known that alveolar mucosa is not capable of inducing keratinization in the superficial epithelial lining [32, 38]. The results of histological examination of healing graft further support this notion [15, 29]. The factors are involved in the improvement of LKT include the initial LKT [9], the amount of connective tissue scaffold coronal to CAF [9], and the apical shift of the mucogingival junction. Regarding the short duration of the present study, it does not seem plausible that the rebound of the mucogingival junction played an important role in the observed enhancement of the keratinized tissue length.

The enhancement of CAL in P-teeth and P-flap averaged 3.87±0.95 and 3.31±1.16 mm, respectively. Meanwhile, changes in probing depth were not significant. The reduction in CAL in other studies was 2.3–5.1 mm accompanied by an insignificant decrease in probing depth [18, 31, 45]. Nonetheless, it is not possible to determine the nature of the newly formed attachment in the lack of histological examination.

Only one case of delayed postoperative bleeding was observed in the present study, which was controlled through utilization of the surgical pack. Del Pizzo et al. [10] reported a similar finding with reference to diminished patient discomfort with connective tissue graft compared to free gingival graft.

Future research may be directed toward histological assessment of the newly formed attachment. The evaluation of the effect of directionality of polarized graft on the microvascularization procedure seems interesting. Moreover, regarding the multipotent nature of progenitor cells of the periosteum, transdifferentiation of these cells to various elements of the periodontal ligament or superficial gingival tissues through polarized orientation of the graft could be the subject of further investigation. A long-term study of the issue of debate—flap orientation—is necessary.

Obviously the application of the connective tissue graft with CAF is efficient for coverage of Miller's class I and II gingival recession defects. Moreover, it could be concluded that the short-term clinical outcome of this surgical method is not affected by the orientation of the connective tissue graft.

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