YEDITEPE UNIVERSITY
INSTITUTE OF HEALTH SIENCES
DEPARTMENT OF PERIODONTOLOGY

TREATMENT OF MULTIPLE GINGIVAL RECESSIONS WITH TWO DIFFERENT APPROACHES

PhD Thesis

İlknur ÖZENCİ, DDS

SUPERVISOR

Prof. Dr. Selçuk YILMAZ

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Başkan : Prof. Dr. Utku ONAN
Üniversite : İstanbul Üniversitesi ....

Üye : Prof. Dr. Selçuk YILMAZ
Üniversite : Yeditepe Üniversitesi ....

Üye : Doç. Dr. Şebnem Dirkan İPÇİ
Üniversite : Yeditepe Üniversitesi ....

Üye : Doç. Dr. Gökser ÇAKAR
Üniversite : Yeditepe Üniversitesi ....

Üye : Yrd. Doç. Dr. Hare GÜRSOY
Üniversite : Yeditepe Üniversitesi ....

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I. SUMMARY

The objective of this controlled study was to evaluate the clinical effectiveness of tunnel technique (TUN) in combination with acellular dermal matrix graft (ADM) on defect coverage, aesthetics and patient satisfaction compared to coronally positioned flap (CAF) plus ADM for the treatment of Miller Class I multiple gingival recessions.

A total of 20 patients (13 females and 7 males) with 58 Miller Class I multiple recessions ≥3 mm were included and divided into TUN+ADM and CAF+ADM groups. At baseline and 12 months after the surgery, plaque index, gingival index, bleeding on probing, probing depth (PD), clinical attachment level, recession height (RH), keratinized tissue height (KT), gingival thickness (GT), and mean and complete defect coverage were evaluated. Patient satisfaction and root coverage aesthetic scores (RES) were also assessed.

Baseline RH in TUN+ADM and CAF+ADM groups was 3.23 ± 0.28 mm and 3.30 ± 0.35 mm, respectively. Intragroup comparisons revealed statistically significant differences at 12 months for all parameters, except PD ($p<0.05$). Gingival thickness increased from 0.82 ± 0.06 mm to 1.40 ± 0.07 mm in TUN+ADM group, and from 0.76 ± 0.06 mm to 1.38 ± 0.09 mm in CAF+ADM group. Mean defect coverage was 75.72% (RH reduction: 2.45 ± 0.20 mm) in TUN + ADM group, and 93.81% (RH reduction: 3.10 ± 0.57 mm) in CAF + ADM group. Complete defect coverage was achieved 37.36% of the teeth (12 out of 31 sites) for the TUN+ADM group, while it occurred 85% of the teeth (23 out of 27 sites) for the CAF+ADM group. Intergroup differences were found to be significant for RH reduction, KT increase, MRC, CRC, and RES ($p<0.05$).

Both techniques were effective in root coverage of multiple recession defects, however better aesthetic results and clinical improvements were achieved with CAF and ADM combination.

Key Words: Acellular dermal matrix graft, tunnel technique, coronally advanced flap, root coverage aesthetic score, multiple gingival recessions.

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III. CONTENTS

IV. ABBREVIATIONS

ADM	Acellular Dermal Matrix Graft
BoP	Bleeding on Probing
CAF	Coronally Advanced Flap
CAL	Clinical Attachment Level
CRC	Complete Root Coverage
CTG	Connective Tissue Graft
GI	Gingival Index
GT	Gingival Thickness
KT	Keratinized Tissue Width
MRC	Mean Root Coverage
PD	Probing Depth
PI	Plaque Index
RES	Root Coverage Esthetic Score
RH	Recession Height
RW	Recession Width
TUN	Tunnel Technique
®	Registered Trademark

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1. INTRODUCTION AND AIM

Gingival recession is defined as an apical shift of the gingival margin from its physiologic position, 1-2 mm coronal to the cemento-enamel junction (1). The recession of the gingiva results in attachment loss and root exposure, and can lead to clinical problems. The main indications for the treatment of recessions include aesthetic patient desires, root hypersensitivity, and difficulty in plaque control (2,3). Gingival recession is a common condition and its extent and prevalence increase with age (4).

Coronally advanced flap (CAF) is an effective periodontal plastic surgical procedure for the treatment of Miller Class I & II multiple gingival recessions with optimum root coverage, and aesthetics (5–8). Coronally advanced flap has been used alone (9–14) or in combination with connective tissue graft (CTG) (13,15–20), barrier membranes (21–30), acellular dermal matrix graft (ADM) (31–58), enamel matrix derivatives (14,48,59–68), xenogeneic collagen matrix (69–75), and biologic mediators (12,55,76–83). Among these techniques, CTG covered by CAF was considered as the gold standard effective and predictable technique for multiple type defects, providing significantly greater degree of root coverage, gingival thickness (GT) and keratinized tissue (KT) increase (6–8,84–87). Previous reports exhibited successful defect coverage with CAF+ADM approach in the treatment of multiple gingival recessions (31–42,47,49–53,55–58,88–90).

Recently, tunnel technique (TUN) proposed as an alternative in the treatment of multiple adjacent recession defects (67,68,91–106). The TUN has been suggested as a minimally invasive, safe and predictable technique that provides better blood supply, quick healing, less scarring and postoperative discomfort (91,107,108). In the literature this technique has been used in combination with CTG (67,68,91–103,107,108), ADM (106,109–112), collagen matrix (104,105), enamel matrix derivatives (103), platelet-rich plasma (111) and growth factors (113) with various degree of success regarding defect coverage. Tunnel technique in combination with CTG was also reported as a predictable technique for multiple recession defects in recent systematic reviews (8,85). However CTG harvesting is often associated with increased patient morbidity, prolonged surgical time, possibility of postoperative complications such as palatal necrosis, pain and bleeding, and difficulty to harvest adequate donor tissue for multiple recession sites (20,114,115). To overcome these problems ADM has been used as an alternative for root coverage procedures, with decreased complications, unlimited donor tissue, good color compatibility, together with GT increase. Acellular dermal matrix graft is an allograft derived from donated human skin that undergoes a multistep proprietary process that removes both the epidermis and the cells that can lead to tissue rejection. By removing all cellular components, the source of disease transmission and immunologic reaction is minimized. The ultrastructural integrity of the extracellular matrix is maintained as the result of freeze-drying process. Acellular dermal matrix graft provides a matrix consisting of type I collagen, elastin, vascular channels, and proteins that support revascularization, cell repopulation and tissue remodelling. After placement, the patient’s blood infiltrates the ADM graft through retained vascular channels, bringing host cells that adhere to proteins in the matrix as a result healing occurs by repopulation and revascularization rather than the scar tissue formation. Acellular dermal matrix graft has been successfully used as a dermal transplant with these special characteristics (116,117).

Successful defect coverage has been long standing objective of periodontal plastic surgery, aspiring to restore the patient’s function, comfort, and aesthetics. Various root coverage procedures and combinations for the treatment of recession defects have been developed and improved with several modifications over the years, with high predictability in Miller Class I and II recession defects. Review of literature reveals ADM in combination with CAF procedure as one of the predictable method to obtain CRC in Miller Class I and II multiple gingival recessions (8,41,42,47,49–51,53,55–58,89,90). On the other hand, limited data is available about the clinical results obtained after TUN plus ADM combination in Miller Class I and II multiple gingival recessions (106,110,111). Only 1 study compared CAF to TUN in combination with ADM in localized recessions and the results were evaluated in short-term, 4 months (110). Therefore the aim of this randomized controlled clinical study was to evaluate clinical effectiveness of ADM in combination with TUN on defect coverage, aesthetics and patient satisfaction compared to CAF plus ADM for the treatment of Miller Class I multiple gingival recessions and present 12 months results.

2. LITERATURE REVIEW

2.1. Gingival Recession and Its Classification

Gingival recession is defined as an apical shift of the gingival margin from its physiologic position, 1-2 mm coronal to the cemento-enamel junction (1). Gingival recession is a common condition (118). Epidemiologic studies have shown that gingival recession can occur in persons with either good or poor oral hygiene (119,120). Patients with high standards of oral hygiene show loss of attachment, marginal tissue recession in buccal surfaces, and they are typically younger individuals (120), whereas those with poor oral hygiene tend to be older individuals whose recession defects affect all tooth surfaces and are associated with periodontal disease (4,121).

Several factors are associated with gingival recession and its etiology is complex. The main risk factors have been postulated to play a role in the etiology of gingival recession are; improper oral hygiene methods (e.g. traumatic tooth brushing, floss, interproximal brush) (122–124), tooth malposition, tooth shape, profile and position in the arch (125,126), alveolar bone dehiscence (127), muscle attachment and frenulum pull (128), periodontal disease and treatment (121), iatrogenic restorative or operative treatment (129), other self-inflicted injuries (e.g. oral piercing, nail biting) (130,131). Biotype is also an important contributing factor to gingival recession (125,132,133).

Over the years, various authors have created numerous recession classification systems (134–137). Miller (136) considered the relationship between the gingival margin and the mucogingival junction, as well as the interproximal alveolar crest and soft tissue height into his classification. His classification system is the most commonly used system to date. The main advantage of Miller's classification is its simplicity and its use in communication despite its shortcomings (138).

Miller’s Classification of Recession

Class I: Marginal tissue recession that does not extend to the mucogingival junction. There is no periodontal loss (bone or soft tissue) in the interdental area, and 100% root coverage can be anticipated.

Class II: Marginal tissue recession that extends to or beyond the mucogingival junction. There is no periodontal loss (bone or soft tissue) in the interdental area, and 100% root coverage can be anticipated.

Class III: Marginal tissue recession that extends to or beyond the mucogingival junction. Bone or soft tissue loss in the interdental area is present or there is malposition of the teeth, which prevents the attempting of 100% root coverage. Partial root coverage can be anticipated.

Class IV: Marginal tissue recession that extends to or beyond the mucogingival junction. The bone or soft tissue loss in the interdental area and/or malposition of teeth is so severe that root coverage cannot be anticipated.

2.2. Periodontal Plastic Surgery

The term periodontal plastic surgery was proposed by Miller in 1988, and defined as the surgical procedures performed to prevent or correct anatomic, developmental, traumatic or disease induced deformities of the gingiva, alveolar mucosa or bone (3).

Periodontal plastic surgery techniques include gingival and edentulous ridge augmentation, root coverage procedures, correction of mucosal defects at implants, crown lengthening, removal of aberrant frenulum, prevention of ridge collapse associated with tooth extraction, gingival preservation at ectopic tooth eruption, aesthetic correction of interdental papilla (139,140). Depending on the increasing aesthetic demands, root coverage procedures for the treatment of gingival recessions are one of the most frequent indications of periodontal plastic surgery (5,7,8,58,87,141).

Several surgical procedures for the coverage of exposed roots caused by gingival recessions have been intended since the beginning of the 20th century. Younger in 1902, Harlan in 1906 and Rosenthal in 1911 (142) first described the use of pedicle or free soft tissue grafts to cover denuded root surfaces. These techniques were abandoned for a long time up to the end of the 1950-es. From these decades different surgical procedures have been described in order to improve clinical parameters such as recession depth, attachment level and width of keratinized gingiva. Surgical procedures used for root coverage are usually classified as free soft tissue graft procedures (143,144) which include epithelialized grafts and subepithelial connective tissue grafts; and pedicle soft tissue graft procedures. Pedicle soft tissue graft procedures include laterally repositioned flap (63,145), double papilla flaps (146), CAF (13,14,19,27–29,46,56,58,65,73,144), semilunar coronally repositioned flap (147–150) and TUN (91,108,151). Early techniques consisted mostly of pedicle flaps, progressing later to the use of a pedicle flap in combination with CTG (13,16–20,94,95,97–100,144,152,153) or guided tissue regeneration (27–30), ADM (33,35,37,42,43,46,50,54,56,58,106,110), enamel matrix derivatives (14,48,63–68), platelet-rich plasma (76,111), platelet-rich fibrin (12,78,154), xenogeneic collagen matrix grafts (72,73,104,105), and growth factors (79,80,82,83).

The main objective of root coverage procedures is to obtain complete coverage of exposed roots, as well as aesthetic blending of the surrounding soft tissues and reduction of root sensitivity without any residual periodontal pocket (84,155). Successful treatment of recession defects is based on the use of predictable periodontal surgery procedures. The selection of proper surgical technique depends on many factors, such as recession defect height (RH) and width (RW), amount of KT adjacent to defect, number of teeth to be treated, interdental papilla height and width, and location of the recession. Also a number of different factors, which are patient related factors: smoking (156–158), poor oral hygiene, and traumatic tooth brushing (10); surgery related factors: flap design (159,160), root surface preparation techniques (161,162), flap tension (163), postsurgical marginal position (164), clinical experience (97,165); site related factors: tooth location, defect configurations (165) and anatomy (136), papilla dimension (166), flap thickness and tissue biotype (167,168) affect the obtained results (165,169).

The total coverage of exposed roots remains a problem for most clinicians despite new surgical techniques and modifications, because the avascular nature of the root surface compromises the graft survival. The predictability of treatments aimed to provide root coverage in cases of localized gingival recessions has been reviewed extensively in several systematic reviews of Miller's Class I and II recession defects (87,170,171). Recent systematic review which assessed the efficacy of periodontal plastic surgeries in the treatment of localized gingival recessions resulted that CAF and CTG combination achieved the best clinical outcomes (87). CAF was associated with higher probability of complete root coverage (CRC) and the combination CAF plus CTG, or enamel matrix derivatives was more effective than CAF alone in terms of CRC and RH reduction (87). Complete root coverage is more frequently observed in CAF plus CTG compared to CAF in combination with enamel matrix derivatives, guided tissue regeneration or collagen matrixes, CTG plus semilunar coronally repositioned flap, free gingival graft and laterally positioned flaps (87). CAF and ADM combination studies showed a large heterogeneity and authors concluded that it had no significant benefits when compared with CAF alone as regards to single recession defects (87).

The treatment of multiple adjacent recession type defects are more challenging with a wider area of root exposure, more extensive avascular surface, limited blood supply, differences in recession depth and tooth position. Besides in order to minimize patient discomfort and to improve clinical outcomes, several recessions must be treated in a single surgical session (85). A couple of techniques and modifications have been suggested for the surgical treatment of multiple adjacent recession defects. The most preferred technique is CAF (10). A supraperiosteal envelope technique in combination with CTG (108), or its evolution as TUN (91,94) are also used to treat multiple gingival recessions. These approaches are developed with the aim of enhancing blood supply, thereby increasing the coverage of denuded roots, improving aesthetic results together with reducing patient morbidity (91,107,108).

Several reviews suggested that periodontal plastic procedures may predictably determine CRC in multiple Miller Class I and II recessions (8,85,86,172). According to a recent consensus report (8), CAF plus grafts such as CTG and ADM showed the higher probability of being best treatment. Modified CAF, performed without vertical incisions, and TUN in combination with CTG presented as the best treatment with the highest probability (8).

2.3. Healing After Root Coverage Procedures by Means of Histology

The nature of the healing processes of root coverage surgical procedures have been investigated in in animal studies (24,83,173–179) and limited human case reports (180–185).

Lee et al. (173) evaluated the efficacy of collagen membrane clinically, histologically and histomorphometrically in the treatment of surgically created recession defects. Eight mongrel dogs treated with collagen membrane plus CAF combination (test group) and CAF alone (control group). Recession height, KT, probing depth (PD), length of sulcular and junctional epithelium, connective tissue adaptation, new cementum, new bone, and defect coverage were evaluated after 4 months of healing. Mean root coverage was 66% for the test group and 56% for the control group. There was no significant difference between treatments related to the clinical parameters ($p>0.05$), except KT, at 4 months. Keratinized tissue significantly increased in CAF group ($p<0.05$). Histomorphometrically, statistically significant increase of new attachment and newly formed connective tissue occurred at test group when compared to control ($p<0.05$). The authors concluded that both procedures could be a successful option in the treatment of gingival recession defects.

de Oliveira et al. (174) compared the histologic results of CAF+ADM alone (control group) and in combination with enamel matrix derivatives (test group) in 6 mongrel dos with 12 experimentally created defects at maxillary canines. Epithelial length, cementum and bone formation, defect extent and gingival position were evaluated. At the end of the study, no statistical difference was found in relation to new cementum formation, new bone, gingival level, and defect extent between the groups (p>0.05). Histometric measurements were 0.86 mm and 0.75 mm for bone regeneration, 0.32 mm and 0.06 mm for cementum regeneration, 3.11 mm and 2.15 mm for attachment level, 5.51 mm and 4.90 mm for defect extent, for the test and control groups, respectively. The epithelial formation was significantly different among groups, which were 2.15 mm in the test and 2.88 mm in the control group (p<0.05). Researchers concluded that enamel matrix derivatives had no additional benefit when used in combination with CAF+ADM.

Sallum et al. (175) compared histometrically the healing of gingival recessions by CAF in combination with ADM (test group) and CAF alone (control group) in the treatment of experimentally created recessions on the maxillary canines of 6 dogs. After 4 months, the obtained outcomes for the evaluated parameters, in the test and control groups were; 2.28 ± 0.92 mm and 2.10 ± 0.46 mm for the epithelial length, 0.05 ± 0.08 mm and 0.06 ± 0.08 mm for the connective tissue adaptation, 2.35 ± 1.55 mm and 2.90 ± 0.96 mm for the new cementum formation, 0.60 ± 1.36 mm and 0.35 ± 0.82 mm for the new bone formation, respectively. Residual RH was 0.88 ± 0.20 mm in the test group, whereas this value was 0.21 ± 0.22 mm in the control group. The increase in GT was 1.63 ± 0.28 mm and 1.16 ± 0.20 mm in the test and control groups, respectively. There were no significant differences in the healing pattern between ADM and CAF combination or CAF procedure alone (p>0.05) but better GT increase might be obtained with the addition of ADM (p<0.05).

Luczyszyn et al. (176) histologically evaluated the incorporation of ADM into gingival tissues in combination with CAF procedure in the treatment of 6 mongrel dogs with surgically created recession defects, on the buccal aspect of the cuspids. At 4 weeks, thick collagen fibers from the ADM were clearly seen in the connective tissue, and some blood vessels were penetrating into the ADM. At 8 weeks, blood vessel penetration was enhanced, and collagen fiber bundles from the ADM were seen sending branches into the connective tissue in all directions. After 12 weeks, the ADM and the connective tissue seemed to be well integrated into a single highly vascularized structure, indicating almost complete incorporation of the ADM. Based on these findings, authors conclude that ADM was capable of consistently integrating into host connective tissue.

Nunez et al. (177) compared clinically and histologically the healing of ADM and CTG when used together with CAF in the treatment of 3 mini pig with surgically created recession defects in one buccal root surface in each quadrant. Clinical parameters such as; RH, RW, clinical attachment level (CAL), PD, KT and histological and histometric analysis such as; length of the epithelium, length of the connective tissue, GT at cemento-enamel junction level, new cementum and bone formation were evaluated. Mean root coverage was 76% in CTG group, whereas 62% in ADM group. The histological interface with the root surface was similar in both groups ($p>0.05$). The apical migration of the epithelium was 1.79 ± 0.46 mm for the CTG and 1.21 ± 0.35 mm for the ADM group. Newly formed cementum was observed with both treatments. According to the results of the study, authors concluded that both grafts showed similar clinical and histological outcomes.

Vignoletti et al. (178) compared clinically and histologically the healing of a porcine derived collagen matrix graft and CAF combination (test group) and CAF alone (control group) in the treatment of 12 minipigs with surgically created recession defects on the buccal aspect of the cuspids. Histometrically, junctional epithelial dimension was shorter in the test group. This value was 2.26 ± 0.23 mm, and 2.79 ± 0.77 mm in the test and control groups, respectively. Conversely, the amount of newly formed cementum was larger in the test group. This value was 1.08 ± 0.41 mm and 0.75 ± 0.25 mm in the test and control groups, respectively. However, the differences between the groups were not statistically significant ($p>0.05$). According to the results of this study, both techniques resulted similar clinical outcomes; on the other hand collagen matrix graft generated more tissue regeneration. The use of a xenogenic porcine collagen matrix graft resulted in the incorporation of the xenograft within the adjacent host connective tissues in the absence of significant inflammation.

Al-Hezaimi et al. (179) compared histomorphometrically the results of CAF with ADM (test group) and CAF alone (control group) in the treatment of 8 beagle dogs. Two maxillary cuspids of each dog divided into test and control groups. Recession height, RW, KT, distance from stent to gingival margin, distance from stent to cemento-enamel junction was evaluated at baseline, right after surgery, 1 and 4 months postoperatively. There was no significant difference between the groups at 4 months in evaluated parameters ($p>0.05$), except KT. Keratinized tissue increase was significantly higher at the control sites ($p<0.05$). They concluded that ADM and CAF combination resulted similar to CAF procedure alone and ADM could decrease the KT amount.

Harris (186) examined the histologic result of the CTG in combination with a partial thickness double pedicle flap in the treatment of teeth number 44 and 45 which are previously planned for extractions for prosthetic reasons. Mean root coverage was 100% and 83% at teeth number 44 and 45 at 6 months after surgery, respectively. At 6 months, the teeth were extracted with block sections and analysed histologically. Analysis demonstrated that healing occurred by long junctional epithelial attachment and no new bone or cementum formation was observed. Based on the histological findings, the CTG with partial thickness double pedicle graft was reported as an effective method in the treatment of gingival recession defects, however true regeneration was not occurred.

Goldstein et al. (181) evaluated the clinical and histomorphometric results of the CTG in the treatment of gingival recessions of the maxillary teeth, in a case study. The graft included palatal periosteum and was placed with the periosteal side facing the exposed bone and root surfaces. At 14 months after surgery, the first maxillary premolars on both sides were extracted for orthodontic therapy. At grafted site, baseline RH was 5 mm and reduced to 0.6 mm together with an attachment gain of 3.9 mm at 14 months. Histologic evaluation revealed that the sulcular epithelium was keratinized, the junctional epithelium was extended over new cementum and also new connective tissue attachment to the new cementum was observed. At the base of the connective tissue, new cementum and periodontal ligament have been formed. The authors suggested that the barrier effect of the periosteum might be part of the explanation for the new attachment obtained and the root coverage and new attachment results compare favorably with those found with the use of barrier membrane techniques for treatment of gingival recessions.

Majzoub et al. (182) evaluated the histological results of CTG combined with CAF procedure in the treatment of bilateral Miller Class I recessions at the maxillary first premolars. Mean root coverage was 83% and 100% at right and the left sites, respectively. Premolars were extracted 12 months after surgery for orthodontic reasons. In both premolars, histological analyses revealed that healing occurred by a long junctional epithelium at the major part of the treated site, and in the apical portion minimal signs of cementum formation were seen. It may be concluded that the use of CTG with CAF achieves adequate clinical coverage of recession type defects. Healing following the CTG procedure was mediated through a long junctional epithelium along the major portion of the roots with a limited area of new attachment and bone formation at the base of the recessions.

Cummings et al. (183) evaluated the histological results of CTG and ADM graft in combination with CAF, in the treatment of 4 patients whose three or more anterior teeth, with a RH of 3 to 6 mm, previously planned for extractions. At 6 months postoperatively extractions were performed and block section biopsies were obtained. The overall histologic outcomes were similar between the CTG and ADM, with good incorporation within the recipient tissues and similar attachment to root surface. Cemental depositions were present within the root notches in both graft materials. It was concluded that both CTG and ADM graft could be successful alternative for root coverage procedures.

Richardson et al. (187) evaluated the histology of the ADM graft used in a healthy uncompromised periodontium. A maxillary canine with normal attachment apparatus and no gingival recession but restoratively hopeless was used. A notch was made surgically in the root surface at the level of alveolar crest, and ADM placed with basement membrane side of the graft against the root and alveolar bone. At 16 weeks, tooth extracted and biopsy specimen was obtained. The histologic results revealed no histologic attachment where the graft in contacts with the root surface, instead a fibrous tissue apposition was occurred. Also, there was no new cementum formation. The apical portion of the graft was resorbed and replaced with host tissues but coronal portion did not show revascularization. Residual ADM remained, but not to the extent of that originally placed.

Camelo et al. (185) evaluated histological results of a porcine-derived, double layer collagen matrix with CAF and CAF alone in the treatment of mandibular first premolars which are previously planned for extractions because of orthodontic treatment. Four months after surgery, block section extractions were performed. Histological results of both specimens demonstrated long junctional attachment and connective tissue adhesion. There was no sign for new cementum, periodontal ligament or alveolar bone regeneration. Both long junctional epithelial attachment and connective tissue adhesion will likely be the outcome when collagen matrix is used in conjunction with a CAF in recession treatment procedures.

In summary, these findings indicate that the wound healing after root coverage procedures with pedicle flaps mostly resulted as soft tissue repair with a long junctional epithelium, and in the most apical portion of the lesion repair by connective tissue attachment can occur where collagen fibres adhere to the root surface (182,183,188–190). Also healing by regeneration by new formation of cementum and functional periodontal ligament in the most apical part of the defect can be occurred (181). Barrier membranes, enamel matrix derivatives, growth factors, autogenic, allogenic and xenogenic soft tissue substitutes for root coverage procedures improve new attachment, but none of them shown complete regeneration (24,71,83,173,174,176–179,183).

2.4. Coronally Advanced Flap

The CAF procedure is based on the coronal shift of soft tissue apical to the denuded root surface (163,191). The original procedure was designed for the coverage of localized defects but the overall design has been developed over time with modifications and improvements coming from animal and human research (12,68,132,163,177,192–194). The CAF is the first choice of surgical procedure when there is adequate KT apical to the recession defect. CAF has been documented as an effective surgical technique for the treatment of multiple gingival recessions (6,8). Optimum root coverage and aesthetic results can be predictably accomplished using this surgical approach (5,10,13,19,51,58,144,177,194–196).

The CAF procedure is a very common approach for root coverage of multiple recessions and several researchers assessed the clinical outcomes of CAF either alone (9–14) or in combination with CTG (13,15–20,144), enamel matrix derivatives (14,48,63–68), guided tissue regeneration (27–30), ADM (31–33,35,37,39,42,43,45,48,49,51–58,88–90), platelet-rich plasma (76), platelet-rich fibrin (12,154), porcine collagen matrix (72,73,75), growth factors (79,80,82,83), button application (197), and in adjunction with low intensity laser therapy (198).

2.4.1. Coronally Advanced Flap in Combination with Connective Tissue Graft For The Treatment of Multiple Gingival Recession Defects

Clinical studies utilizing CTG in combination with CAF for root coverage of multiple recession defects are the most widely performed studies in the literature (13,15–20,144). The systematic review of the literature indicated that CTG with CAF procedure for root coverage of Miller Class I and II multiple recession defects, enhanced the probability to obtain CRC and improved RH reduction (6–8,85).

Wennström & Zucchelli (144) compared the clinical outcomes of CTG in combination with CAF (test group) or CAF alone (control group) in the treatment of 67 patients with 103 Miller Class I recession defects $\geq$ 3 mm. Baseline RH and RH reduction in the test and control groups were 4.0 ± 1.0 and 3.8 ± 0.7 mm; and 4.1 ± 0.9 and 3.9 ± 0.5 mm, respectively. Mean root coverage and CRC in the test and control groups were 96.1% and 72%; 96.4% and 74% at 6 months evaluation, respectively. At the 24 months evaluation, MRC and CRC in the test and control groups were 98.9% and 80%; 97.1% and 88%. Keratinized tissue increase was 2.6 ± 0.1 mm and 0.4 ± 0.5 mm at 6 months, and 2.8 ± 0.1 mm and 1.1 ± 0.1 mm in the test and control groups at 24 months evaluation, respectively. There was no difference among the groups at the follow-up examinations ($p>0.05$), except KT increase was significant in favour of test group both at 6 and 24 months ($p<0.05$). The authors concluded that changes of tooth brushing habits might be of greater importance than increased gingival thickness for long-term maintenance of the surgically established position of the gingival margin.

Cetiner et al. (16) evaluated the outcomes of CTG in combination with CAF in the treatment of 10 patients with 52 multiple Miller Class I & II multiple recession defects ≥3 mm. Baseline RH was 3.11 ± 0.80 mm and it was reduced to 3.0 ± 0.53 mm twelve months after the surgery. Mean root coverage and CRC were 96.1%, and 80%, respectively. There was statistically significant difference in terms of RH and RW reduction, KT and attachment gain at 12 months ($p<0.05$). They concluded that the CTG covered by CAF was effective for the treatment of multiple gingival recessions in terms of root coverage and KT increase.

Pini-Prato et al. (13) compared and evaluated the long-term outcomes of CAF with CTG (test group) and CAF alone (control group) in the treatment of 13 patients with 93 maxillary Miller Class I, II & III bilateral multiple recession defects. Baseline RH in the test and control groups was 3.6 ± 1.3 mm, and 2.9 ± 1.3 mm, respectively. Mean root coverage and RH reduction in the test and control groups were 89.65% and 3.0 ± 1.3 mm; 83.33% and 2.6 ± 1.3 mm at 6 months, respectively. Complete root coverage was 34% and 57% in the test and control groups, respectively. There was no statistically significant difference between the groups in terms of RH reduction and CRC, at 6 months ($p>0.05$). At the 5 year, CRC was 52% for the test group, whereas it was 35% for the control group. The marginal relapse was observed in the control group, whereas a coronal improvement of the margin was noted in the test group between the 6 months and 5-year evaluation. They concluded that CAF and CTG combination provided better long-term results than CAF alone in the treatment of multiple gingival recessions.

De Sanctis et al. (18) evaluated the results of CTG combined with CAF for the treatment of 10 patients with 26 Miller Class I or II multiple recessions ≥ 3 mm in the posterior mandibular area. Baseline RH was 3.40 ± 0.83 mm. One year after the surgery, RH reduction and MRC were 2.12 ± 0.50 mm and 91.2%, respectively. Cases with worse initial conditions resulted with greater RH reductions. Complete root coverage was 50%. Baseline KT was 0.57 ± 0.46 mm and it was increased to 2.52 ± 0.25 mm at 12 months. Recession height reduction, KT and CAL gain were statistically significant at 12 months when compared to baseline ($p<0.05$). The authors concluded that CAF in combination with CTG could be proposed as a valid therapeutic approach for multiple recession defects in mandibular posterior areas.

Zucchelli et al. (19) compared the short and long term results of CTG in combination with CAF (test group) and CAF alone (control group) in the treatment of 50 patients with at least two Miller Class I and II gingival recessions ≥ 2 mm. The surgical technique was the modification of CAF without vertical incisions. Baseline RH was 3.15 mm and 3.05 mm in the test and control groups, and it was reduced to 0.09 mm and 0.3 mm at 5 year, respectively. In the control group among the 73 treated defects, CRC was achieved in 68 (at 6 months), 65 (at 1 year) and 57 (at 5 years) recession defects. In the test group among the 76 treated defects, CRC was achieved in 68 (at 6 months), 66 (at 1 year), and 69 (at 5 years) recession defects. There was no statistically significant difference between the groups in terms of RH reduction and CRC at 6 months and 1 year ($p>0.05$). At 5 years, statistically greater recession reduction, and greater KT increase observed in the test group ($p<0.05$). CAF alone resulted better post-operative course and better color match at 1 and 5 years. However, CAF in combination with CTG resulted better CRC in spite of the worse color match due to keloid formation.

Zuchelli et al. (20) evaluated the effect of graft dimensions on patient morbidity, root coverage and aesthetic outcomes in the treatment of 60 Miller Class I and II gingival recessions ≥3 mm with CAF plus extra-orally deepithelized free gingival graft. In the test group the graft thickness was < 2 mm and the height was 4 mm (small graft), whereas in the control group the graft thickness was ≥ 2 mm and the height was equal to bone dehiscence (big graft). Baseline RH was 3.80 ± 0.96 mm in the test group and it was reduced to 0.13 ± 0.35 mm at 1 year; whereas this value was 3.93 ± 0.96 mm for the control group and reduced to 0.17 ± 0.35 mm at 1 year. Complete root coverage was

83% and 80%, for the test and control groups, respectively. The difference was not significant between the two groups in terms of RH reduction, CRC, KT increase ($p>0.05$). Greater GT increase was achieved in the control group ($p<0.05$). They concluded that the small graft with reduced thickness and height was resulted with less patient morbidity, better aesthetic results and the results were similar for both groups in root coverage.

Results of all above mentioned studies indicate that the most predictable and long-term stabile results were achieved when CAF is combined with CTG. (13,16–18,20,42,143,144). However, disadvantages related to CTG harvesting may sometimes limit clinicians and alternatives to CTG might be a choice (20).

2.4.2. Coronally Advanced Flap and Different Combinations For The Treatment of Multiple Recession Defects

As an alternative to CTG such as; barrier membranes (27–30), enamel matrix derivatives (14,48,63–68), platelet rich plasma (76), platelet rich fibrin (12,154), collagen matrix (72,73,75), and growth factors (79,80,82,83) were also used in combination with CAF.

Guided tissue regeneration-based root coverage was first described by Pini Prato et al. in 1992 (21). The rationale behind utilizing barrier membranes for root coverage procedures was to stimulate the proliferation of periodontal ligament cells on the root surface and possibly the formation of new bone and cementum, by impeding the apical migration of epithelial cells (22). Barrier membranes in the treatment of gingival recessions have been proposed and tested by many authors. (23,25,27–30,199,200)

Leknes et al. (27) compared the 1 and 6 years results of biodegradable membrane with CAF (test group) and CAF alone (control group) in the treatment of 20 patients with bilateral Miller Class I or II gingival recessions ≥3 mm. Baseline RH was 4.10 ± 0.90 mm and 3.60 ± 1.00 mm in the test and control groups, respectively. Mean root coverage and RH reduction in the test and control groups were 51.2% and 2.10 ±

0.60 mm; 61.1% and 2.20 ± 0.30 mm at 1 year, respectively. Baseline KT was 2.4 ± 0.7 mm and 2.6 ± 0.5 mm in the test and control groups, respectively. Keratinized tissue increase was 0.60 ± 0.10 mm and 0.4 ± 0.1 mm in the test and control groups at 1 year, respectively. Gingival thickness was only measured at the 6-year evaluation. Gingival thickness increase was 0.89 ± 0.16 mm in the test group, whereas a decrease of 0.80 ± 0.20 mm was observed in the control group. Greater RH reduction was observed in the control group at the 6-year evaluation ($p<0.05$). They concluded that CAF procedure is a simple and reliable method and the placement of a biodegradable membrane underneath the flap did not seem to improve neither the short nor the long-term results, also long-term outcome stability seems to be critically dependent on a continuous follow-up program with re-instruction in non-traumatic brushing habits.

Banihashemrad et al. (28) compared the clinical outcomes of resorbable collagen membrane with CAF procedure (test group) and CAF alone (control group) in the treatment of 7 patients with 22 Miller Class I & II gingival recessions ≥3 mm. Baseline RH was 4.46 ± 0.31 mm and 3.64 ± 0.20 mm in the test and control groups, respectively. Mean root coverage and RH reduction in the test and control groups were 67.88% and 3.00 ± 0.36 mm; 57.42% and 2.00 ± 0.27 mm at 6 months evaluation, respectively. Baseline KT was 3.73 ± 0.30 mm and 3.91 ± 0.29 mm in the test and control groups, respectively. Keratinized tissue increase was 0.36 ± 0.28 mm in the test group, but a decrease of 0.18 ± 0.23 mm was observed in the control group. The difference was significant between the two groups in terms of RH, RW reduction, and CAL gain in favour of the test group, at 6 months ($p<0.05$). They concluded that Miller Class I & II gingival recessions were manageable defects with the guided tissue regeneration application.

Cardaropoli & Cardaropoli (29) evaluated the results of bioabsorbable membrane and a demineralized xenograft combined with CAF procedure (test group) and CAF alone (control group) in the treatment of 16 patients with 20 Miller Class I or II gingival recessions in maxillary canines or premolars ≥ 2 mm. Baseline RH and RH reduction for the test and control groups were 2.50 ± 0.71 mm and 2.35 ± 0.78 mm; 2.70 ± 0.54 mm and 2.50 ± 0.28 mm, respectively. Mean root coverage was 93.33% and

92.49% in test and control groups at 6 months, respectively. Complete root coverage was 70% and 60% in test and control groups, respectively. Baseline KT in the test and control group was 2.45 ± 0.72 mm and 2.60 ± 0.66 mm, respectively. Keratinized tissue increase was 0.80 ± 0.54 mm and 0.55 ± 0.55mm in the test and control groups, respectively ($p>0.05$). Baseline GT in the test and control groups was 0.85 ± 0.17 mm and 0.93 ± 0.21 mm, respectively. Gingival thickness increase was 0.88 ± 0.18 mm and 0.17 ± 0.12 mm in the test and control groups, respectively. There was a significant difference in favour of test group for GT ($p<0.05$). They concluded both procedures offer predictable root coverage, but significant GT increase might be achieved with the guided tissue regeneration procedure when compared to CAF procedure alone.

Rosetti et al. (30) compared the long-term clinical outcomes of guided tissue regeneration combined with demineralized freeze-dried bone allograft (test group) and CTG (control group) with CAF procedure in the treatment of 12 patients with 24 Miller Class I and II bilateral gingival recessions in canines or premolars. Baseline RH was 3.75 ± 0.90 mm and was decreased to 0.50 ± 0.60 mm at 30 months in the test group. The same value was 4.20 ± 0.80 mm and was decreased to 0.30 ± 0.65 mm in the control group. Mean root coverage was 87% and 95.5% for test and control groups at 30 months, respectively. Baseline KT was 1.0 ± 0.5 mm and 1.0 ± 0.6 mm in test and control groups, respectively. Keratinized tissue increased to 3.4 ± 0.6 mm and 4.5 ± 1.2 mm in test and control groups, respectively. There was no statistically significant difference in the evaluated parameters between the groups ($p>0.05$), except KT. Significant KT increase was observed in favour of control group when a comparison was performed between baseline and 30 months ($p<0.05$). They concluded that both guided tissue regeneration and CTG techniques lead to favourable and long-term stable results in the treatment of gingival recession defects, however CTG resulted with greater KT increase.

Although guided tissue regeneration based root coverage procedures with resorbable membranes resulted comparable to CAF+CTG procedures (27–30,201), better results are achieved with Miller Class I defects with a tissue thickness of >1 mm; therefore, case selection is critical (202). Proper clinical technique, including a properly trimmed membrane and coronally advanced flap, is also very important. The challenges associated with membrane exposure should also be considered.

Enamel matrix derivative, is an amelogenin derivative that has been developed to promote periodontal regeneration (203–205). Its biological potential was tested with a CAF for the treatment of gingival recessions by various authors (14,48,63–68).

McGuire et al. (65) compared the long term clinical outcomes of enamel matrix derivatives in combination with CAF (test group) and CAF+CTG (control group) in 9 patients with 18 Miller Class I & II gingival recessions. Baseline RH was 4.00 ± 0.00 mm and 4.00 ± 0.50 mm for test and control groups, respectively. Mean root coverage and RH reduction in test and control groups were 83.3% and 3.33 ± 0.87 mm; 89.8% and 3.67 ± 1.12 mm at 10 year evaluation, respectively. Complete root coverage was 55.6% and 77.8% in test and control groups, respectively. Baseline KT in the test group was 2.67 ± 0.71 mm, whereas in the control group it was 2.56 ± 0.73 mm. Keratinized tissue increase was 0.89 ± 1.27 mm and 1.44 ± 0.73 mm in test and control groups, respectively. At 10 years, there was no statistically significant difference between the groups for any measured parameter ($p>0.05$). The authors concluded that both CAF+CTG and CAF plus enamel matrix derivatives resulted stable, clinically effective and similar for all the evaluated parameters, at 10 years after surgery.

Cordaro et al. (14) evaluated the clinical outcomes of enamel matrix proteins in combination with CAF (test group) and CAF alone (control group) for the treatment of 10 patients with 58 maxillary Miller Class I & II multiple gingival recessions ≥2 mm. Baseline RH was 3.12 ± 1.11 mm and 2.93 ± 0.83 mm in test and control groups, respectively. Recession height reduction in test and control groups was 2.50 ± 0.73 mm and 2.29 ± 0.62 mm, respectively at 6 months. Mean root coverage was 82.8 ± 14% and 80.7 ± 20% at 6 months, in test and control groups, respectively. Complete root coverage was 31% in the test group, whereas it was 45% in the control group at 6 months. After 24 months, RH reduction in test and control groups was 2.31 ± 0.87 mm and 2.03 ± 0.69 mm, respectively. Mean root coverage was 74.8% ± 16% and 71.0 ± 22% at 24 months, in test and control groups, respectively. Complete root coverage was

17% and 24% in test and control groups at 24 months, respectively. Baseline KT was 2.72 ± 0.61 mm and 2.78 ± 0.65 mm in test and control groups, respectively. Keratinized tissue increase was 0.28 ± 0.41 mm and 0.31 ± 0.51 mm in test and control groups at 6 months evaluation, respectively. At 24 months, KT increase from baseline was 0.41 ± 0.42 mm and 0.36 ± 0.44 mm in the test and control groups, respectively. No statistically significant differences were found at any stage of the study for any parameter (p>0.05). They concluded that the additional use of enamel matrix proteins did not significantly improve the outcomes when compared to CAF procedure alone for the treatment of multiple recessions.

Roman et al. (66) evaluated the clinical results of enamel matrix derivative in combination with CTG (test group) and CTG alone (control group) with CAF procedure in the treatment of 42 patients with Miller Class I and II gingival recessions ≥ 2 mm. Mean root coverage and RH reduction for the test and control groups were 82.25% and 2.91 ± 0.95 mm; 89.75% and 2.91 ± 1.29 mm 1 year after surgery, respectively. Complete root coverage was 56.5% for the test group and 70.6% for the control group. The differences in RH change for the two techniques after 1 year, were not statistically significant (p>0.05). They stated that the present study failed to demonstrate any additional clinical benefits when enamel matrix derivative was added to CTG plus CAF.

Data is conflicting for root coverage of Miller's Class I and II recession type defects, with or without EMD. The addition of EMD to a CAF has been to be beneficial in some studies (61,62,65), while others do not find any additional effect (14,59,60,66). According to recent systematic reviews, the addition of enamel matrix derivatives improves the outcomes of CAF in single recession defects, but has not provide any additional benefit in multiple gingival recessions (8,87).

Platelet concentrated graft combined with CAF procedure has been proposed in periodontal plastic surgery to increase the clinical outcomes (76,77). Platelet contains many autogenous growth factors including platelet-derived growth factor, insulin-like growth factor and transforming growth factor-beta and these are regulating several biologic activities both genetic and cellular levels (206).

Lafzi (77) et al. evaluated clinical efficiency of CAF procedure alone (control group) or in combination with platelet-rich plasma (test group) in the treatment of 6 non-smoker patients with 20 bilateral Miller Class I gingival recessions 2 mm. Baseline RH was 3.3 ± 0.8 mm for the test group, and 3.6 ± 0.9 mm for the control group. Mean root coverage and RH reduction in the test and control groups were 61.8% and 2.0 ± 0.1 mm; 65.0% and 1.2 ± 0.7 mm at 3 months evaluation, respectively. Baseline KT in the test group was 2.9 ± 0.9 mm, whereas in the control group it was 2.4 ± 0.7 mm. KT decrease was 0.1 ± 0.1 mm and 0.1 ± 0.2 mm in the test and control groups, respectively. When both treatments were compared at 12 months, there was no statistically significant difference between the groups in terms of all evaluated parameters ($p>0.05$). They concluded that while platelet-rich plasma enhanced the outcomes of CAF especially throughout the first month post-operatively, it offered no clinical advantage over CAF alone during the subsequent 2 months.

The results of the studies suggest that platelet-rich plasma may only affect early wound healing that can be considered as one of the important factors in the prevention of the surgically established gingival margin (6,77).

The autologous platelet rich fibrin, which consists of platelets, growth factors and cytokines, was aimed to use in plastic periodontal surgery procedures to enhance the clinical outcomes, but results of the studies indicated beneficial effect only on soft tissue wound healing (12,154,207).

Jankovic et al. (154) compared the clinical outcomes of platelet-rich fibrin membrane (test group) to enamel matrix derivatives (control group) in combination with CAF in the treatment of 20 patients with Miller Class I and II maxillary gingival recessions. Recession height was 4.10 ± 1.05 mm and 3.90 ± 1.00 mm at baseline, and 1.05 ± 0.45 mm and 1.15 ± 0.65 mm at 12 months in test and control groups, respectively. Mean root coverage and CRC were 72.1% and 65% for the test group, whereas these values were 70.5% and 60% for the control group. Keratinized tissue was 1.45 ± 0.86 mm and 1.30 ± 0.56 mm at baseline; 1.62 ± 0.28 mm and 1.90 ± 0.81 mm at

12 months in test and control groups, respectively. There was no statistically significant difference between the two groups for any of the evaluated parameters, at 12 months (p>0.05). Based on the results of this study, they concluded that the use of platelet-rich fibrin membrane did not showed any advantage, besides the obtaining of blood presents additional discomfort to the patient.

Aroca et al. (12) evaluated the clinical effectiveness of platelet-rich fibrin addition to a modified CAF (test group) and compared to CAF alone (control group) for the treatment of 20 patients with 67 Miller Class I & II multiple recessions. Baseline RH was 2.9 ± 1.1 mm and 2.5 ± 0.9 mm in the test and control groups, respectively. Recession height reduction in test and control groups was 2.3 ± 0.5 mm and 2.3 ± 0.5 mm at 6 months evaluation, respectively. At 6 months, MRC was 80.7% and 91% in test and control groups, respectively. At 6 months, CRC was 52.2% for the test group, and it was 74.6% for the control group. Baseline KT in the test group was 2.78 ± 1.08 mm, and it was 2.85 ± 1.23 mm in the control group. KT decreased to 0.24 ± 0.23 mm and 0.48 ± 0.34 mm in test and control groups at 6 months evaluation, respectively. Baseline GT in the test group was 1.1 ± 0.4 mm, in the control group, it was 1.1 ± 0.3 mm. Gingival thickness increased 0.3 ± 0.1 mm in both groups and remained unchanged at 6 months evaluation. The difference between the groups at 6 months was statistically significant in terms of MRC, GT and attachment gain, and RW reduction (p<0.05). They concluded that modified CAF was a predictable treatment for multiple defects, whereas addition of a platelet-rich fibrin membrane did not provide an additional effect on root coverage.

A newly developed porcine derived bioresorbable collagen matrix has been introduced as an alternative to CTG in periodontal plastic surgery. Successful results have been reported in the treatment of Miller Class I & II recession defects in conjunction with CAF (69,70,72,74,185).

Cardaropoli et al. (72) compared the clinical outcomes of a porcine derived collagen matrix (test group) to CTG (control group) in combination with CAF procedure in the treatment of 18 patients with 22 Miller Class I and II gingival recession defects. Recession height was 3.09 ± 0.63 mm in the test group and 3.05 ± 0.65 mm in the control group at baseline. Mean root coverage and RH reduction in test and control groups were 94.32%, 2.86 ± 0.39 mm; and 96.97%, 2.95 ± 0.69 mm at 12 months, respectively. Attachment gain was 2.41 ± 0.83 mm and 2.95 ± 0.82 mm in test and control groups, respectively. Keratinized tissue gain was 1.23 ± 0.61 mm and 1.27 ± 0.65 mm in test and control groups, respectively. From baseline to 12 months GT changed from 0.82 ± 0.34 to 1.82 ± 0.51 mm in the test group, and from 0.86 ± 0.39 mm to 2.09 mm in the control group. There was no significant difference between the both treatments for any of the evaluated parameter ($p>0.05$). Based on the results of this study, the researchers stated that collagen matrix represents a possible alternative to CTG.

Jepsen et al. (73) evaluated the clinical outcomes of collagen matrix in combination with CAF procedure (test group) or CAF alone (control group) in the treatment of 45 patients with 90 Miller I, II recession defects. At 6 months, MRC was 75.29% for the test and 72.66% for the control group. Complete root coverage was 36% for the test and 31% for the control group. At 6 months, the difference between the groups in terms KT and GT increase was statistically significant in favour of test group ($p<0.05$). Larger recessions (3 mm) treated with collagen matrix showed higher root coverage (72.03% versus 66.16%, $p = 0.043$), as well as more gain in KT and GT. They concluded that the addition of collagen matrix to CAF procedure did not improve the clinical parameters in terms of root coverage, but enhanced GT and width of KT when compared with CAF alone. For the treatment of larger defects, collagen matrix and CAF combination was more effective.

2.4.3. Coronally Advanced Flap in Combination with Acellular Dermal Matrix Graft For The Treatment of Multiple Recession Defects

Review of the literature revealed that the CTG increase the predictability of the root coverage procedures, however CTG harvesting is often associated with increased patient morbidity associated with the second surgical site, prolonged surgical time, and possibility of postoperative complications such as palatal necrosis, pain and bleeding

(114). In patients with shallow palate or thin palatal tissues, and also for the treatment of multiple gingival recession defects, it becomes difficult to harvest sufficient donor tissue. To overcome these disadvantages ADM has been used as a successful alternative to CTG (31–33,35,37,39,42,43,45,48,49,51–58,88–90). Acellular dermal matrix is an allograft derived from donated human skin that undergoes a multistep proprietary process that removes both the epidermis and the cells that can lead to tissue rejection. By removing all cellular components, the source of disease transmission and immunologic reaction is minimized. The ultrastructural integrity of the extracellular matrix is maintained as the result of freeze-drying process. Acellular dermal matrix provides a matrix consisting of type I collagens, elastin, vascular channels, and proteins that support revascularization, cell repopulation and tissue remodeling. After placement, the patient's blood infiltrates the ADM graft through retained vascular channels, bringing host cells that adhere to proteins in the matrix as a result healing occurs by repopulation and revascularization rather than the scar tissue formation. Acellular dermal matrix has been successfully used as a dermal transplant with these special characteristics (116,117,208). Acellular dermal matrix has been used in dentistry for root coverage procedures (31,35,48,81,175,177,209,210), soft tissue ridge augmentation procedures (88), soft tissue augmentation around dental implants (211), also as a biological barrier for hard and soft tissue regeneration (90,212).

Acellular dermal matrix has been used in combination with CAF (31,34,35,37,44) and compared to CAF alone to evaluate its clinical outcomes in previous studies (41,46,47,56,58,213).

Woodyard et al. (213) compared the results of ADM in combination with CAF (test group) or CAF alone (control group) in the treatment of 24 patients with Miller Class I or II recession defects ≥ 3 mm. Baseline RH in the test group was 3.46 ± 0.89 mm, whereas in the control group it was 3.27 ± 0.56 mm. Mean root coverage, CRC, RH reduction in the test and control groups were 99%, 92%, 2.35 ± 0.78 mm and 67%, 33%, 2.19 ± 0.95 mm at 6 months evaluation, respectively. Baseline KT in the test group was 1.79 ± 1.27 mm, and it was 1.54 ± 1.16 mm in the control group. KT increase was 0.81 ± 0.96 mm in the test group, whereas a decrease of 0.33 ± 1.05 mm in the control group was observed. Baseline GT at sulcus base in the test group was 0.76 ± 0.21 mm, in the control group it was 0.75 ± 0.21 mm. GT increase was 0.40 ± 0.26 mm and 0.03 ± 0.23 mm in the test and control groups, respectively. After 6 months, there was a significant difference between the treatment groups in terms of RH reduction; GT increase and attachment gain in favour of the test group ($p<0.05$). They concluded that CAF and ADM combination leads to significant increase in GT when compared with CAF alone and root coverage was significantly improved with the use of ADM.

Cortes et al. (46) evaluated the clinical outcomes of ADM+CAF combination (test group) to CAF procedure alone (control group) in the treatment of 13 patients with bilateral Miller Class I gingival recessions ≥ 3 mm, in maxillary canines and premolars. Baseline RH was 3.46 ± 0.85 mm for the test group and 3.58 ± 0.57 mm for the control group. The difference between the groups, in terms of RH change was not statistically significant after 6 and 12 months ($p>0.05$). At 24 months, RH was 1.15 ± 0.80 mm for the test group and 1.62 ± 1.00 mm for the control group. Mean root coverage for the test and control group was 76.18%, and 71.19% at 6 months; 68.04% and 55.98% at 24 months, respectively. Baseline GT for the test and control groups were 1.05 ± 0.27 mm and 1.05 ± 0.22 mm; it was increased to 1.56 ± 0.27 mm and 1.18 ± 0.21 mm at 24 months, respectively. Gingival thickness and KT increase was greater in the test group when compared to control after 24 months ($p<0.05$). They concluded that root coverage can be achieved in Miller Class I recessions with or without the use of ADM graft, but grafted sites resulted greater GT and less relapse of the recession.

Andrade et al. (50) evaluated the clinical outcomes of surgical technique of CAF procedure in combination with ADM in the treatment of 15 patients with bilateral Miller Class I or II gingival recessions ≥2 mm. The control group was treated with a broader flap and vertical releasing incisions, and the test group was treated with the same flap design but without vertical releasing incisions. Baseline RH was 2.88 ± 0.81 mm for the test group, and 2.73 ± 0.76 mm for the control group. Mean root coverage and RH reduction in test and control groups were 74.32% and 2.16 ± 0.16 mm; 83.28% and 2.27 ± 0.23 mm at 12 months evaluation, respectively. Complete root coverage was 40.0% in the test group, and 53.360.0% in the control group. Baseline KT in the test group was

1.94 ± 1.66 mm, and in the control group it was 2.73 ± 0.76 mm. Baseline GT in the test group was 0.48 ± 0.29 mm, and in the control group it was 0.55 ± 0.21 mm. Keratinized tissue and GT increase were 0.56 ± 0.15 mm, 0.16 ± 0.65 mm in the test group, whereas these values were 0.60 ± 0.24 mm, 0.41 ± 0.48 mm in the control group at 12 months evaluation, respectively. After 12 months, there was a significant reduction in RH in both groups and the difference was not significant between the groups with regard to root coverage (p>0.05). They concluded that both surgical techniques in combination with ADM, resulted significant RH reduction after 12 months, but the group with releasing vertical incisions leads to statistically significant difference in KT increase, after 12 months (p>0.05).

Ayub et al. (54) evaluated the effect of marginal tissue position after CAF procedure in combination with ADM in the treatment of 15 patients with 30 bilateral Miller Class I and II recessions ≥ 3 mm. In the test group, the ADM was placed 1 mm apical to the cemento-enamel junction and the flap 1 mm coronal to cemento-enamel junction, in the control group both flap and ADM were positioned at the level of cemento-enamel junction. At baseline, RH in the test and control groups was 3.30 ± 0.29 mm and 3.32 ± 0.34 mm, at 6 months, this value was 0.38 ± 0.25 mm and 1.14 ± 0.30 mm, respectively. Mean root coverage was 88.37% for the test and 65.85% for the control group. At 6 months, the difference was significant in terms of CAL gain, RH and gingival recession area reduction, in favour of test group (p<0.05), however there was no difference between the groups for KT and GT (p>0.05). They concluded that, although both flap and graft position resulted in significant clinical improvements, tested flap and ADM position produced significantly greater defect coverage.

Thombre et al. (56) evaluated the effectiveness of ADM in combination with CAF (test group) or CAF alone (control group) in the treatment of 20 patients with 43 Miller Class I and II multiple gingival recessions > 2 mm. Baseline RH was 3.0 ± 0.9 mm for the test group and 2.8 ± 0.7 mm for the control group. Recession height reduction and MRC were 2.7 ± 1.0 mm and 90% in the test group, whereas 1.8 ± 0.9 mm and 66% for the control group, respectively. There was statistically significant difference in RH reduction and CAL gain in favour of test group, at 6-month evaluation (p<0.05). They concluded that ADM in combination with CAF procedure is an effective procedure for the treatment of multiple gingival recessions.

Ahmedbeyli et al. (58) compared the clinical outcomes of ADM in combination with CAF (test group) and CAF alone (control group) in the treatment of 24 patients with 48 Miller Class I multiple recessions ≥ 3 mm with thin tissue biotype (GT<0.8 mm). Baseline RH in the test group was 3.25 ± 0.34 mm and in the control group it was 3.21 ± 0.26 mm. Mean root coverage, RH reduction was 94.84%, 3.08 ± 0.51 mm and 74.99%, 2.37 ± 0.83 mm in test and control groups at 12 months evaluation, respectively. Complete root coverage was 83.33% in the test and 50% in the control group. Baseline parameters were similar in both groups. The difference between the groups at 12 months was statistically significant in terms of RH reduction, CAL gain, KT and GT, MRC and root coverage aesthetic score (RES) in favour of test group (p<0.05). There was a significant positive correlation between GT and MRC. Overall patient satisfaction was similar in both groups (p>0.05). They recommended CAF and ADM combination as an efficient approach for the treatment of multiple gingival recessions with thin tissue biotype.

Coronally advanced flap combined with ADM extensively compared to CAF combined with CTG in previous studies (32,36,38–40,42,45,53,89).

Harris (32) evaluated the effectiveness of ADM (test group) and compared it to CTG (control group) with CAF procedure in 50 healthy patients with 107 gingival recessions ≥2 mm. Baseline RH was 3.1 ± 0.8 mm for the test group, and 3.4 ± 0.8 mm for the control group, and they were reduced to 2.9 ± 0.5 mm and 3.2 ± 0.5 mm at 12 weeks after surgery, respectively. Mean root coverage and CRC were 95.8% and 87.7% in the test group and 96.2% and 81.0% in the control group, respectively. Baseline KT in the test group was 1.6 ± 0.9 mm and it was increased to 2.7 ± 0.8 mm, whereas in the control group it was 1.3 ± 0.8 mm and it was increased to 3.3 ± 0.6 mm at 12 weeks. At 12 months, there was a significant difference only in PD and KT change in favour of the control group (p<0.05). The author resulted that ADM and CTG demonstrated similar clinical and esthetical results.

Novaes et al. (36) compared the clinical results of ADM (test group) and CTG (control group) in combination with CAF procedure in the treatment of 9 patients with 30 bilateral Miller Class I or II gingival recessions ≥3 mm. All baseline parameters of both groups were similar. At 6 months, MRC and RH reduction in the test and control groups were 60.0% and 2.1 ± 1.0 mm; 66.7% and 1.83 ± 0.83 mm, respectively. Test group demonstrated 0.63 ± 0.85 mm increases in KT and control group increase of 1.26 ± 0.88 at 6 months compared to baseline. There was no statistically significant difference between the groups in terms of RH reduction; CAL gain, PD reduction and KT increase at 6 months (p>0.05). They concluded that both graft material produced aesthetic root coverage; therefore ADM might be a substitute for palatal donor tissue.

Paolantonio et al. (39) compared the clinical results of ADM (test group) and CTG (control group) in combination with CAF procedure in the treatment of 30 patients with Miller Class I or II gingival recessions ≥3 mm. Baseline RH was 4.75 ± 1.20 mm for the test group, and 4.80 ± 1.14 mm for the control group. Mean root coverage and RH reduction in test and control groups were 83.33% and 4.00 ± 1.06 mm; 88.80 % and 4.20 ± 0.86 mm at 12 months evaluation, respectively. Complete root coverage was 26.6% in the test group, and 46.6% in the control group. Keratinized tissue increase was 0.53 ± 0.51 mm and 1.93 ± 1.03 mm in the test and control groups, respectively. Gingival thickness increase was 1.03 ± 0.34 mm and 1.14 ± 0.44 mm in the test and control groups, respectively. The difference between the groups in terms of RH, CAL and GT improvements was not statistically significant (p>0.01), but KT increase was significantly greater in favour of control group (p<0.01). Complete healing of the surgical procedure was observed at 8.93 ± 1.33 and 6.20 ± 1.01 weeks after suture removal in the test and control groups, respectively (p<0.01). They concluded that the results of CTG and ADM were similar in terms of defect coverage, however significantly greater KT increase and quicker complete healing were obtained with CTG (p<0.01).

Harris (42) evaluated the short-term (mean 12.3 to 13.2 weeks) and long-term (mean 48.1 to 49.2 months) root coverage results obtained with ADM (test group) or

CTG (control group) in combination with CAF procedure in 25 patients with Miller Class I or II gingival recessions ≥ 2 mm. Mean root coverage was 93.4% for ADM in the short-term period and it was 96.6% for CTG. Mean root coverage in long-term period was 97.0% for CTG. These values were statistically greater than MRC obtained in the long-term period for ADM, which was 65.8% ($p<0.01$). Long-term results of ADM group revealed that MRC was greater in multiple type defects (70.8%) than single type defect (50.0%). They concluded that the results with the CTG were better than ADM in the long-term period.

Hirsch et al. (45) compared the effectiveness of ADM (test group) or CTG (control group) in combination with CAF procedure with 2-year follow-up in the treatment of 166 patients with Miller Class I or II gingival recessions. Baseline RH was 4.2 ± 0.1 mm for the test group, and 4.9 ± 0.2 mm for the control group. Mean root coverage and RH reduction in the test and control groups were 98.8% and 3.95 ± 0.06 mm; 99.1% and 4.77 ± 0.16 mm at 24 months evaluation, respectively. Keratinized tissue increase was 2.2 ± 0.04 mm and 3.00 ± 0.10 mm in the test and control groups, respectively. They concluded that both ADM and CTG resulted similar predictable clinical outcomes in short and long term, however significantly greater difference in KT and CAL gain was achieved with CTG ($p<0.05$).

Rahmani et al. (89) compared the clinical results of ADM (test group) or CTG (control group) in combination with CAF procedure in the treatment of 14 patients with 20 Miller Class I & II gingival recessions. Baseline RH was 4.05 ± 1.04 mm for the test group, and 3.70 ± 0.63 mm for the control group. Mean root coverage and RH reduction in the test and control groups were 72.08% and 2.90 ± 0.81 mm; 70.12% and 2.60 ± 0.97 mm at 6 months evaluation, respectively. Keratinized tissue increase was 2.95 ± 0.69 mm and 2.50 ± 0.97 mm in test and control groups, respectively. When both treatments were compared at 6 months, there was no significant difference in any of the evaluated parameters ($p>0.05$). They concluded that ADM and CTG demonstrated similar results, and ADM could be a successful alternative in the treatment of gingival recession defects.

Moslemi et al. (53) compared the long-term results (5 year) of ADM (test group) or CTG (control group) in combination with CAF procedure in the treatment of 16 patients with bilateral Miller Class I & II gingival recessions ≥2 mm. Baseline RH was 2.87 ± 0.91 mm for the test group, and 3.33 ± 1.39 mm for the control group. Mean root coverage and RH reduction in the test and control groups were 85.4% and 2.6 ± 1.1 mm; 69.1% and 2.2 ± 1.1mm, at 6 months evaluation, respectively. Complete root coverage was 73.3% in the test group, and 26.7% in the control group. Baseline KT in the test group was 1.90 ± 1.31 mm, whereas in the control group it was 1.93 ± 1.28 mm. Keratinized tissue increase was 0.97 ± 1.01 mm and 0.80 ± 1.26 mm in the test and control groups at 6 months evaluation, respectively. When both treatments were compared at 6 months, there was a significant difference in terms of CRC in favour of the test group ($p<0.05$). At 5 years, MRC and RH reduction in test and control groups were 54.6% and 1.6 ± 1.2 mm; 39.8% and 1.5 ± 1.4 mm, respectively. Complete root coverage was 20.0% in the test group, and 13.3% in the control group. Significant relapses were detected in CRC, RH and RW reductions in both groups with no statistically significant difference ($p>0.05$). Compared with baseline, KT did not increase in ADM sites over 5 years evaluation period. They concluded that the clinical results of ADM and CTG at 5 years in terms of CRC and RH reduction were similar. Both techniques showed a significant relapse associated with returning to horizontal tooth brushing habit ($p<0.05$). Keratinized tissue increase was stable in CTG treated sites, but returned to baseline values in ADM-treated cases.

In conclusion, CTG might be the choice of the clinicians as the gold standard despite the challenges it offers not only to the clinician but also to the patients (35). However, ADM is also a successful alternative to CTG (32,36,39,45,53,89).

Acellular dermal matrix graft has also been used with the addition of enamel matrix proteins (48,51,64), autologous gingival fibroblasts by tissue-engineering (81), recombinant human platelet-derived growth factor (55) for not only enhancing the clinical results but also long term stability.

Shin et al. (48) compared the effectiveness of root coverage using ADM with enamel matrix proteins (test group) and ADM alone (control group) in combination with CAF in the treatment of 14 patients with 82 bilateral single or multiple Miller Class I, II or III recession defects ≥2 mm. Baseline RH in the test group was 3.58 ± 0.48 mm, and it was 3.74 ± 0.60 mm in the control group. Mean root coverage, RH reductions were 79.4%, 2.05 ± 1.00 mm and 73.4%, 1.93 ± 1.32 mm in the test and control groups at 6 months evaluation, respectively. Baseline KT in the test group was 3.68 ± 1.68 mm, and it was 3.65 ± 1.61 mm in the control group. Keratinized tissue increase was 0.89 ± 0.66 mm and 0.52 ± 0.56 mm in test and control groups, respectively. There was a significant difference between the groups in terms of KT increase in favour of the test group when compared baseline to 6 months ($p<0.05$). They concluded that the use of enamel matrix proteins in association with ADM resulted with a statistically significant effect on KT increase ($p<0.05$), however this combination revealed no significant effects in attachment gain or percentage of root coverage ($p>0.05$).

Pourabbas et al. (51) compared the clinical results of enamel matrix proteins with ADM combination (test group) to ADM alone (control group) in combination with CAF procedure in the treatment of 15 patients with 36 Miller Class I or II recession defects ≥2 mm. Baseline RH in the test group was 5.13 mm, and it was 5.11 mm in the control group. Mean root coverage, RH reductions were 84.9%, 2.04 mm and 89.5%, 2.14 mm in test and control groups at 6 months evaluation, respectively. Baseline KT in the test group was 2.11mm, and 2.16-mm in the control group. Keratinized tissue increase was 0.80 mm and 1.03 mm in test and control groups, respectively. The differences were similar in terms of the all evaluated parameters between the groups ($p>0.05$). They concluded that the enamel matrix proteins application did not improve the clinical outcomes of ADM in combination with CAF in the treatment of gingival recession defects.

Although an increase in KT is observed with the addition of enamel matrix derivatives to ADM, the results are controversial. This combined treatment will be very cost effective for the patient with limited benefits. When deciding the treatment approach this point should be considered.

Barker et al. (52) compared the effectiveness of two different ADM products which are Puros Dermis Graft (test group) or Alloderm (control group) in combination with CAF procedure in the treatment of 14 patients with 52 Miller Class I or III single or multiple recession defects ≥2 mm. Baseline RH in the test group was 3.50 ± 1.47 mm and it was decreased to 0.67 ± 0.76 mm, at 6 months. In the control group, baseline RH was 3.79 ± 1.47 mm and decreased to 0.65 ± 0.76 mm, at 6 months. Mean root coverage was 81.4%, and 83.4%; in Miller Class I defects it was 85% and 87.3 %; in Miller Class III defects it was 61.3% and 62.5% for test and control groups at 6 months evaluation, respectively. Baseline KT in test group was 2.60 ± 1.13 mm, and it was 2.83 ± 1.17 mm in the control group. Keratinized tissue increase was 0.25 ± 0.30 mm and 0.11 ± 0.32 mm in the test and control groups, respectively. There was no statistical or clinical difference in terms of all evaluated parameters and on postoperative pain between the groups (p>0.05). They concluded that both materials were resulted similar clinical outcomes and both ADM materials can be used as a successful alternative to CTG in the treatment of gingival recession defects.

Carney et al. (55) compared the clinical outcomes of ADM with recombinant human platelet-derived growth factor and CAF (test group) or ADM and CAF alone (test group) in the treatment of 17 patients with 40 bilateral single or multiple Miller Class I, II and III gingival recession defects ≥ 2 mm. Recession height was 2.98 ± 1.00 mm at baseline and decreased to 0.96 ± 0.88 mm and 0.65 ± 0.76 mm at 3 and 6 months in the test group, respectively. For the control group, RH was 3.04 ± 1.10 mm at baseline, decreased to 0.95 ± 0.98 mm and 0.76 ± 0.84 mm at 3 and 6 months, respectively. Mean root coverage was 69% for the test group and 76.7% for the control group at 6 months. For Miller Class I defects MRC were 84.1% at test group and 84.7% for the control group. The test group showed 51.5% MRC and the control group showed 60.8% MRC for the Miller Class III defects. There was no significant difference between the groups, both groups improved from baseline to 6 months, but not from 3 to 6 months, regarding all evaluated parameters (p>0.05). Based on the results of this study, they concluded that there was no additional benefit derived from adding recombinant human platelet-derived growth factor to CAF and ADM combination.

Jhaveri et al. (81) compared the clinical efficacy of ADM seeded with autologous gingival fibroblasts (test group) to CTG (control group) when used in combination with CAF procedure in the treatment of 10 patients with bilateral Miller Class I and II gingival recession defects ≥ 2 mm, in a case series. Gingival biopsy was taken from the attached gingiva, consisting of the epithelium and connective tissue, than the gingival tissue placed into *in vitro* cell cultivation to obtain fibroblasts. Baseline RH in the control group was 2.3 mm, and reduced to 0.3 mm at 3 months, 0.4 mm at 6 months, after surgery, whereas in the control group baseline RH was 2.8 mm, reduced to 0.4 mm at 3 months and 0.5 mm at 6 months. Mean root coverage obtained at the 6 months was 83.3% for both test and control groups. The difference was statistically significant in gingival inflammation, the control group showed more inflammation at 1 week, 2 weeks and 3 weeks after surgery ($p<0.05$). There were no significant differences between the groups for other all evaluated parameters ($p>0.05$). Based on the results of this study they concluded that cell-seeding therapy might be a promising approach for treating Miller Class I and II recession defects.

According to a recent systematic review, the probability of being best treatment in terms of RH reduction are associated with the usage of CAF and a grafting procedure, such as ADM (8). Acellular dermal matrix has shown to provide a stable grafting when added to CAF for multiple recession defects, being only minimally inferior to CTG (32,36,39,45,53,89). The use of CTG significantly increased the CRC in the long term, when compared to CAF alone (13,16–18,20,42,143,144).

2.5. Tunnel Technique

The TUN is proposed as minimally invasive, safe and predictable technique in the treatment of multiple gingival recessions (8,85). The use of TUN preserves the intermediate papillae which provide maximum blood supply and may accelerate the initial wound healing and causes less scarring (108). Due to minimal trauma at the recipient site, the procedure causes less postoperative discomfort (91). Another advantage of the TUN is that of preserving the continuity of the gingival papillae by creating a pouch to contain graft material (91,108), and also by positioning this pouch and tunnel coronally, it is possible to completely cover the graft material (109,110,112). Tunnel technique has been used in combination with CTG (67,91–93,95–102), collagen matrix (104,105), platelet-rich plasma (111), growth factors (113) and ADM (106,109–112).

2.5.1. Tunnel Technique in Combination with Connective Tissue Graft For The Treatment of Multiple Recession Defects

When the TUN approach is considered, mostly case reports and randomized controlled trials in combination with CTG take place in the literature (67,91–93,95–102,107).

The TUN evolved from the technique described by Raetzke in 1984 (153). The method involved the CTG is placed in an envelope created by a partial thickness incision without vertical incisions around the defect. This envelope technique offers some advantages, such as minimal surgical trauma at recipient site, good healing due to maximum contact between graft and host tissues, aesthetic appearance. But indications for this technique are limited with localized areas of recession with or without sufficient keratinized gingiva.

In 1994 Allen (108) modified the envelope technique and demonstrated a supraperiosteal envelope technique in soft tissue grafting for root coverage for multiple adjacent areas of gingival recession. The unique characteristic of this procedure was that the interdental papillae were left intact, individually created envelopes connecting each other under the papillae. He used partial thickness dissection at the recipient area without vertical incisions and the CTG was placed in the tunnel but it did not need to be completely covered as long as the graft dimension was sufficient to ensure graft survival. An advantage of not covering the graft completely was that additional KT was gained, whereas the disadvantage was that the exposed tissue might not be an exact color match. He also reported the clinical results and CRC was 61% (14 of 23 sites) (107). Five of the 9 remaining sites had 75% coverage, and 4 had coverage from 20% to

67%. The average root coverage for all sites was 84% (107). Allen also classified the results according to depth; CRC was achieved in 10 (83%) of 12 shallow defects and 4 (40%) of 10 moderate defects. Shallow defects averaged 95% coverage and moderate defects 73% coverage. The author stated that the supraperiosteal envelope technique offers several advantages in the treatment of adjacent gingival recession defects. Surgical trauma at the recipient site is minimal; graft nutrition is augmented by lateral and papillary blood vessels, the aesthetic appearance of the surgical area are preserved by maintaining the integrity of involved papillae.

Zabalegui et al. (91) reported the results obtained with CTG and a modification of the envelope technique for the treatment of multiple adjacent gingival recessions in the anterior areas of the mouth. They suggested the same partial thickness dissection procedure described by Allen (107,108), however they create a tunnel under the areas of gingival recession by means of undermining the tissue far beyond the mucogingival line without raising the papillae so that there is enough relaxation to allow the entrance of a large CTG underneath the tunnel. A suturing technique to allow this graft to slip through the tunnel under the gingival tissues and to secure and stabilize the graft covering the recessions is described. They treated 21 teeth and one year after surgery reported a mean RH reduction of 3 mm, which represents a MRC of 91.6% and CRC of 66.7%. The authors suggested that this new technique offered many advantages such as better adaptation and stability of the graft, prevention of apical retraction, adequate early healing and high predictable root coverage.

Santarelli et al. (92) presented a case report of CTG employing the TUN in the anterior maxilla. Partial thickness dissection with the TUN was performed and a releasing vertical incision extending beyond the mucogingival line at the distal corner of the papilla was made between the maxillary left central and lateral incisors. The CTG introduced into the tunnel through this single vertical incision, where the interdental papilla between adjacent teeth remained intact. One year after surgery, PD was less than 2 mm, and CRC was 100%. The position of the mucogingival junction remained the same, but the amount of keratinized gingiva on the left central incisor increased by 2 mm. They suggest that this technique is valuable for the treatment of Miller Class I or II recessions when aesthetics are of paramount importance and also the use of TUN preserves the papillary height between two mucogingival defects.

Tözüm & Dini (94) described a modified TUN and CTG for the treatment of adjacent gingival recession defects. The recipient sites were prepared by partial thickness dissection. However, the partial thickness dissection was converted to full thickness in the more apical direction through the mucogingival junction, to preserve major gingival vessels inside the flap. Fourteen adjacent maxillary gingival recession defects (13 Miller Class II and 1 Miller Class III) were treated and authors reported ~3.67 mm attachment gain, ~3.28 mm root coverage and ~0.64 mm PD reduction, after 8 months postoperatively. The MRC was 95% and ranged from 50% to 100%. On the basis of their results, they proposed that CTG with a modified TUN, in which the partial-thickness flap is converted to a full-thickness flap in more apical direction, results in adequate early healing and highly predictable root coverage in adjacent gingival recessions.

Tözüm et al. (95) compared the clinical outcomes of the modified TUN and the Langer & Langer (152) technique for CTG in the treatment of 31 patients with Miller Class I and II gingival recessions. Baseline RH was 3.50 ± 0.14 mm for cases treated with the TUN, and 3.47 ± 0.18 mm for the Langer & Langer technique. Six months after the surgery, RH reduction and CAL gain were 3.36 ± 0.17 mm and 3.93 ± 0.27 mm, 2.56 ± 0.19 mm and 2.44 ± 0.34 mm in the TUN and Langer & Langer groups, respectively. The MRC was 96.4% in TUN and 75.5% in the Langer & Langer groups. At 6 months, statistically significant differences were found between the TUN and Langer & Langer groups for RH reduction and CAL gain, in favour of TUN group ($p<0.05$), whereas probing depths did not show a statistically significant change after treatment in both groups ($p>0.05$). They concluded that the use of CTG in combination with TUN might enhance root coverage and CAL gain compared to the Langer & Langer technique.

Tözüm (214) also compared the short-term (8 months) and long-term (36 months) results of CTG and modified TUN. The MRC was 95% and 92.2% at 8 and 36 months after surgery, respectively. The differences between the baseline and the 8 months follow-up, and the baseline and the 36-month follow-up of both CAL and RH were statistically significant ($p<0.0003$). The RH reduction was 3.79 mm and 3.14 mm, and CAL gain was 3.93 mm and 3.28 mm, at 8 and 36 months, respectively. There was 0.64 mm reduction in PD at both evaluation periods. According to these results, author stated that CTG in combination with modified TUN offers predictable and long-term stable results, in the treatment of gingival recession defects.

Saadoun (96) evaluated the clinical outcomes of TUN combined with CTG in the treatment of Miller Class I and II adjacent recession defects on both maxillary lateral incisors and canines, in a case report. He reported uneventful healing and 100% CRC of all treated teeth, with a successful aesthetic result on both sides one year after surgery.

Dembowska & Drozdzik (97) compared the treatment outcomes of CTG combined with TUN in 28 Miller Class I and in 20 Class II multiple adjacent gingival recession defects in 18 patients. Baseline RH was 2.6 mm for Class I recessions and 3.1 mm for Class II group. Baseline RW was 3 mm and 3.5 mm for Class I and II groups, respectively. Recession height and RW were 0.2 mm and 0.2 mm, 0.4 mm and 0.4 mm at 6 months after the surgery, in Class I and II groups, respectively. Statistically significant reductions in RH and RW were observed at 6 and12 months after surgery, as compared to baseline ($p<0.05$). At 12 months, RH and RW of the Class I recessions were both 0.1 mm. In Class II recessions, RH and RW were 0.3 mm and 0.2 mm. Mean root coverage and CRC of Class I recessions was 97% and 78.6% at 6 months, respectively. Twelve months after surgery, MRC and CRC was 99.1% and 79.2%, respectively. Mean root coverage and CRC of Class II recessions were 96.6% and 60.0%, 98.9% and 72.2% at 6 and 12 months, respectively. Keratinized tissue of Class I recessions at baseline was 3.6 mm. This value was 5.6 mm and 5.1 mm at 6 and 12 months after surgery, respectively. In Class II recessions, KT at baseline was 1.0 mm. This value was 4.5 mm and 3.8 mm at 6 and 12 months, respectively. The KT values in each class of recession before surgery and at 6 and 12 months after surgery showed statistically significant differences ($p<0.006$). The authors concluded that CTG in combination with TUN resulted in significant root coverage and KT increase in the treatment of both Miller Class I and II multiple recessions.

Zuhr et al. (98) evaluated the use of microsurgical approach in the TUN, in a case report. Alterations in the technique include an undermining split flap preparation with newly developed microsurgical instruments to minimize trauma and ensure a better blood supply for the CTG. Anterior maxillary teeth of a non-smoker male patient treated with TUN+CTG. They reported successful coverage at 12 months and stable aesthetic results 2 year after surgery. They also stated that the use of microsurgical concept, including microsurgical blades and suture materials, improves wound healing and establishes better aesthetic result.

Riberio et al. (99) evaluated the 3 year clinical results of CTG in combination with TUN in the treatment of Miller Class I and III multiple gingival recessions, in a case report. For the treatment of recessions on maxillary right central incisor to left first premolar, CTG was removed from the palate and then split cross sectional to increase the graft dimension. Recession height was 3.0 ± 0.7 mm at baseline. Recession height reduction and MRC was 2.2 ± 0.7 mm, and 74.2% at 3 years after surgery, respectively. They observed that the healing process was uneventful, and the patient did not report pain or discomfort during the overall postoperative period. The authors concluded that in a long-term evaluation, TUN with the elongated CTG was used successfully for treatment of multiple gingival recessions with an increase of the soft tissue volume and gain of KT.

Georges et al. (100) compared the effects of the surgical experience level in the treatment of single or multiple recession defects with TUN in combination with CTG. Three surgeons treated thirty-six gingival recessions in 35 healthy patients. Two of them were seniors (A and B) who experienced periodontal surgery for more than 10 years and a third surgeon (C) was a postgraduate student who had no experience in this technique. Baseline RH was 2.5 ± 0.99 mm (A), 4.23 ± 1.20 mm (B), and 4.43 ± 1.45 mm (C). Recession height reduction was 2.12 ± 1.12 mm for operator A, 3.81 ± 1.40 mm for operator B, and 3.60 ±1.25 mm for operator C, at 6 months. Mean root coverage and

CRC obtained by the three operators were 85% and 66.7% for operator A, 89% and 50% for operator B, and 81% and 33.3% for operator C, respectively. Baseline RH showed statistically significant differences between the operators ($p<0.0001$), however MRC were similar. Baseline KT was 1.43 ± 0.55 mm (A), 1.12 ± 0.62 mm (B), and 1.14 ± 0.99 mm (C). Keratinized tissue gain was statistically significant different among operators which was 2.02 ± 0.95 mm for operator A, 3.13 ± 1.07 mm for B, 3.12 ± 1.49 mm for C ($p<0.0001$). According to the results of this study they considered TUN as a tolerant technique, and successful clinical outcomes of CTG combination have been reported irrespective of the initial dimensions of recession and experience of operators for the treatment of multiple or single recession-type defects.

McLeod et al. (102) evaluated the results of TUN in combination with CTG in the treatment of multiple Class III gingival recessions in the mandible, in a case report. Donor site deepithelized with a sharp instrument and then a large and uniform abundant CTG harvested from the palate. Baseline RH was ranged from 1 to 6 mm, CAL was ranged from 3 to 8 mm, and KT was ranged from 1 to 4 mm. At 3 months after surgery, there was improvement in GT, KT gain, and RH reduction. Complete root coverage was occurred in 3 of the 10 treated teeth, and MRC of the 7 remaining teeth was between 80% and 90%. The patient's root sensitivity was resolved on both sides of the mandible. They concluded that partial palatal deepithelization and application into TUN, is practical and successful with increased GT, KT, and MRC.

Zuhr et al. (67) evaluated the outcomes of a surgical root coverage with 3 dimensional measuring methods obtained with TUN+CTG and CAF with enamel matrix derivatives in the treatment of 47 recession defects in 24 patients who had at least one Miller Class I and II buccal gingival recession defect not exceeding 5 mm in depth. Recession height and CAL were evaluated with optically scanned study models. Baseline RH was 1.93 ± 0.57 mm and 1.69 ± 0.63 mm for the TUN and CAF groups, and RH reductions in the TUN and CAF groups were 1.94 ± 0.57 mm and 1.17 ± 0.42 mm at 12 months, respectively. Mean root coverage at 6 months was 99.2% and 72.2% for the TUN and CAF groups, and this value was 98.4% and 71.8% at 12 months for the TUN and CAF groups, respectively. Complete root coverage was 78.6% and 21.4% for

TUN and CAF groups at 12 months evaluation, respectively. Baseline KT was 3.26 ± 1.25 mm and 2.95 ± 1.06 mm for the TUN and CAF groups, respectively. At 12 months KT increased 0.62 ± 0.83 mm in the TUN group, whereas it decreased 0.34 ± 0.51 mm in the CAF group. At 12 months, the difference between the groups in terms of MRC, CRC, RH reduction and KT increase was statistically significant, in favour of TUN group ($p<0.05$). There was no statistically significant difference between the groups in terms of patient morbidity and overall satisfaction ($p>0.05$). Root coverage aesthetic score revealed a significant difference between the groups in favour of tunnel group ($p<0.05$). The authors concluded that TUN+CTG resulted in significantly better clinical outcomes compared to CAF plus enamel matrix derivatives and digital measuring method provided high accuracy in the evaluation of root coverage treatment outcomes.

Data from the above mentioned literature indicated that TUN combined with CTG is a predictable technique for the treatment of Miller Class I and II recessions.

2.5.2. Tunnel Technique and Different Combinations For The Treatment of Multiple Recession Defects

Attempts are made to use different materials to overcome the complications associated with CTG harvesting, or to increase the success of the clinical outcomes. Platelet-rich plasma (111), enamel matrix derivatives (103), growth factors (113) and collagen matrix (104,105) are used in combination with TUN.

Aroca et al. (103) evaluated the clinical outcomes of TUN in combination with CTG and enamel matrix derivatives (test group) or TUN with CTG (control group) in the treatment of 20 patients with at least three adjacent gingival recessions >2 mm (with at least one defect ≥3 mm), on both sides of the mouth. Baseline RH was 3.5 ± 1.5 mm for the test group and 3.2 ± 1.4 mm for the control group. Mean root coverage and RH at 1 year evaluation in test and control groups were 82% and 0.8 ± 1.1 mm; 83% and 0.6 ± 0.9 mm, respectively. Complete root coverage was 38% at 1 year (8 of the 20 surgeries). There was no significant difference in any of the evaluated parameters between the two treatment groups at 1 year ($p>0.05$). They concluded that the TUN with

CTG is predictable for the treatment of multiple class III recession-type defects and the addition of enamel matrix derivatives does not enhance the mean clinical outcomes.

Zadeh (113) presented a case report to introduce a minimally invasive approach for the treatment of both single and multiple Miller Class I and II maxillary anterior gingival recession defects by vestibular incision subperiosteal tunnel access and platelet derived growth factor BB. Access to the surgical site facilitated by a vertical incision in the maxillary anterior frenulum, and recombinant human platelet derived growth factor BB saturated resorbable collagen membrane introduced to tunnel through that incision, placed over root dehiscence and sutured. The membrane and mucogingival complex was advanced coronally and then stabilized. Beta-tricalcium phosphate hydrated with recombinant human platelet derived growth factor BB (GEM21S) is placed between the collagen membranes and the maxillary facial osseous tissues. The author evaluated the results of this approach in two patients with 8 Miller Class I and II maxillary anterior adjacent defects (ranging 2 to 4 mm). Complete root coverage was observed in both cases one year after surgery, and these results were stable at 35 month follow up of one patient and at 20 month follow up of other. He concluded that this growth factor mediated approach was advantageous for the treatment of gingival recession defects, especially in the aesthetic zone.

Molnar et al. (105) evaluated the safety and efficacy of TUN and collagen matrix combination in the treatment of 8 patients who had at least 3 multiple Miller Class I and II adjacent gingival recessions. A total of 42 recessions were treated. Baseline RH and RW were 2.0 ± 0.5 mm and 3.4 ± 0.8 mm and they were reduced to 0.3 ± 0.3 mm and 1.0 ± 1.3 mm at 12 months, respectively. Baseline KT and GT were 2.9 ± 1.3 mm and 1.0 ± 0.3 mm and they were increased to 3.4 ± 1.3 mm and 1.3 ± 0.4 mm, respectively. Mean root coverage was 84%, CRC considering patient and tooth level was 25% and 71% at 12 months after surgery, respectively. Recession height, RW, KT and GT improved statistically significantly ($p<0.0001$), at 12 months compared to baseline. They concluded that the treatment of Miller Class I and II multiple adjacent gingival recessions by TUN and collagen matrix combination might result in statistically and clinically significant CRC.

Aroca et al. (104) compared the clinical outcomes of TUN in combination with collagen matrix (test group) or CTG (control group) in the treatment of 22 patients with a total of 156 Miller Class I and II multiple adjacent gingival recessions >2 mm on both sides of the maxillary or mandibular arch. Baseline RH was 1.9 ± 0.6 in the test group, and decreased to 0.6 ± 0.5 mm at 12 months, whereas in the control group, it was 1.8 ± 0.5 and 0.2 ± 0.3 mm, respectively. Mean root coverage was 71 % in the test group, whereas it was 90 % in the control group at 1 year. Complete root coverage was 42% and 85% in the test and control groups, respectively. The difference between the two groups in terms of MRC and CRC was statistically significant in favour of control group ($p<0.05$). There was no statistically significant difference between the test and control groups in terms of KT, RW and PD ($p>0.05$). Mean surgery time was statistically significantly lower in the test group (42.5 ± 4.8 min.) when compared with the control group (58.6 ± 6.6 min.) ($p<0.05$). The number of 100% satisfaction was higher in the test group compared with the control, but was not statistically significant ($p>0.05$). They concluded that collagen matrix can be used as an alternative to CTG by reducing surgical time and patient morbidity, but provide lower CRC than CTG in the treatment of Miller Class I and II multiple gingival recessions when used together with TUN.

2.5.3. Tunnel Technique in Combination with Acellular Dermal Matrix Graft for the Treatment of Multiple Gingival Recessions

Previous studies revealed that ADM combined with CAF approach work as well as a CTG in terms of defect coverage and predictability in Miller Class I and II defects (8). To date, a few studies performed to evaluate the clinical outcomes of ADM in combination with TUN (106,109–112).

Papageorgakopoulos et al. (110) compared the clinical outcomes of TUN (test group) and CAF (control group) procedures in combination with ADM in 24 patients with Miller Class I or II recession ≥ 3 mm. Baseline RH in the test group was 3.1 ± 0.3 mm, whereas in the control group it was 3.4 ± 0.8 mm. At 4 months evaluation, MRC, CRC, and RH reductions were 78% and 95%, 50% and 83%, 2.4 ± 1.0 mm and 3.2 ±

0.9 mm in the test and control groups, respectively. Baseline KT in the test group was 1.2 ± 0.8 mm, whereas in the control group it was 1.0 ± 0.5 mm. Keratinized tissue increase was 0.6 ± 0.5 mm and 0.8 ± 0.7 mm in the test and control groups, respectively. Baseline GT at sulcus base in test group was 0.7 ± 0.2 mm, whereas in the control group it was 0.6 ± 0.1 mm. The increase in gingival thickness at sulcus base was 0.1 ± 0.2 mm and 0.5 ± 0.2 mm in the test and control groups, respectively. Creeping attachment from 2 to 4 months was 0.2 ± 0.4 mm for the both TUN and CAF groups. There was no statistically significant difference between the groups in any of evaluated parameters ($p>0.05$). The authors concluded that the difference between the groups was considered clinically significant.

Modarressi & Wang (106) evaluated the results of TUN+ADM in the treatment of Miller Class I and II recession defects in 5 patients with 2 to 5 adjacent gingival recession defects on the maxillary incisors, canines, or premolars, with one of the recessions ≥ 2 mm. Baseline RH was 2.79 ± 1.24 mm and decreased to 1.10 ± 0.71 mm at 1 year. Baseline RW was 3.32 ± 1.52 mm and it was reduced to 1.22 ± 1.66 mm at 1 year. Baseline GT 3 mm apical to the gingival margin was 1.13 ± 0.33 mm and it was 1.28 ± 0.31 mm at 1 year postoperatively. Baseline KT was 2.95 ± 1.74 mm and it was reduced to 1.84 ± 1.15 mm at 1 year. Mean root coverage was 75.46%, 58.67%, 60.5% at days 90, 180 and 1 year, respectively. The authors suggested that root coverage with TUN+ADM could be a successful alternative to traditional techniques, especially for multiple recession defects in maxillary premolar and anterior teeth.

Shepherd et al. (111) compared the clinical outcomes of platelet-rich plasma in combination with ADM and TUN (test group) or TUN with ADM (control group) in the treatment of 18 patients with 18 Miller Class I or II recession ≥ 3 mm. Baseline RH was 3.6 ± 1.0 mm for the control group, which was reduced to 1.0 ± 1.0 mm at the 4 months examination. Baseline RH was 3.3 ± 0.7 mm for the test group, which was reduced to 0.4 ± 0.7 mm at the 4 months. Mean root coverage was 90% and 70% for the test and control groups, respectively. Baseline GT at the sulcus base was 0.6 ± 0.1 mm for the test group and 0.8 ± 0.2 mm for the control group. It was increased to 1.0 ± 0.4 for the test group and 1.2 ± 0.6 mm for the control group at the 4 months. Baseline KT in the test group was 1.4 ± 0.8 mm, whereas in the control group it was 1.3 ± 0.7 mm. Keratinized tissue increase was 0.6 ± 0.8 mm and 0.4 ± 0.5 mm in the test and control groups, respectively. When both treatments compared at 4 months there were no statistically significant differences between the groups in any of the evaluated parameters ($p>0.05$). According to these results they concluded that TUN plus ADM with the use of platelet-rich plasma improved recession defect coverage compared to sites treated without platelet-rich plasma, although the difference was not statistically significant, clinical benefits were observed.

Mahn (112) evaluated the clinical outcomes of TUN in combination with ADM in a patient with multiple adjacent gingival recessions in the aesthetic zone, in a case study. The author stated that CRC was achieved at all sites 8 weeks after surgery and the soft tissue architecture was natural and aesthetic in appearance. He concluded that the use of TUN in combination with ADM could be successful alternative in the aesthetic correction of multiple adjacent gingival recessions.

Consequently, the available data appear to suggest that ADM in combination with CAF and TUN as one of the predictable methods to obtain CRC in Miller Class I multiple gingival recessions. Based on the information we obtained from literature, our hypothesis is no statistically significant differences are observed with respect to clinical parameters RH, RW, MRC, CRC, KT, GT, patient centered outcomes and aesthetics between the TUN or CAF approach in combination with ADM in the treatment of multiple gingival recessions.

However to our knowledge, no randomized controlled trial has been yet published comparing the TUN with CAF procedure in multiple recession defects using the ADM for 12 months evaluation period. Therefore the aim of this randomized controlled clinical study was to evaluate clinical effectiveness of ADM in combination with TUN on defect coverage, aesthetics and patient satisfaction compared to CAF plus ADM for the treatment of multiple gingival recessions. Primary outcome variable was the assessment of defect coverage. The secondary outcome variables included the assessment of KT, GT, patient centered outcomes and aesthetics.

3. MATERIAL AND METHODS

3.1. Study Population

The patients, who participated in this study, were referred to the Yeditepe University Faculty of Dentistry, Department of Periodontology for the treatment of gingival recession defects. All risks and benefits involved in the procedures were explained to the patients before they signed an informed consent form. A total of twenty patients (13 females and 7 males) with at least 2 sites with a Miller Class I recession defects ≥ 3 mm were enrolled in this study.

This clinical study was designed as parallel, randomized, controlled clinical trial. Ten patients were treated with TUN combined with ADM (TUN+ADM group) and 10 patients were treated with CAF combined with ADM (CAF+ADM group). Patients were randomly assigned to the TUN+ADM or the CAF+ADM treatment groups with the use of coin toss.

3.2. Patient Selection

Criteria for patient selection were:

- Presence of at least two Miller Class I recession defects ≥ 3 mm on maxillary or mandibular incisors, canines or premolars
- PD<3 mm
- No systemic diseases that could influence the outcome of the therapy
- Non-smoker
- Not pregnant or lactation period
- Absence of endodontically treated teeth
- Absence of bruxism and occlusal trauma
- Absence of previous root coverage procedure

3.3. Study Design

Each patient received a full diagnostic workup including full mouth periapical radiographs, study casts, intraoral photographs. After diagnostic workup, scaling and polishing were performed using ultrasonic devices[1] and Gracey curettes[2] and detailed oral hygiene instructions were given 8 weeks before the surgery. The patients were instructed to perform a non-traumatic (roll) brushing technique. The use of a soft bristle tooth brush twice a day and interdental flossing was recommended. Occlusal loading adjustment, cervical restoration correction was performed, if indicated. Patients were re-evaluated 8 weeks after initial therapy and only patients with plaque index (PI) (215) and gingival index (GI) (216) ≤1 were qualified for the operation. Individual acrylic occlusal stents were prepared for probe positioning to record CAL, PD, RH and KT. Gingival thickness and RW was also measured at baseline and 12 months after surgery. The study design was explained in Figure 1.

[1] **Piezon® OEM built-in kit**, EMS, Switzerland.
[2] **Gracey** SG ¾, $^{5}/_{6}$, $^{7}/_{8}$, **Mini-Five** SAS ¾, Hu-Friedy, USA.

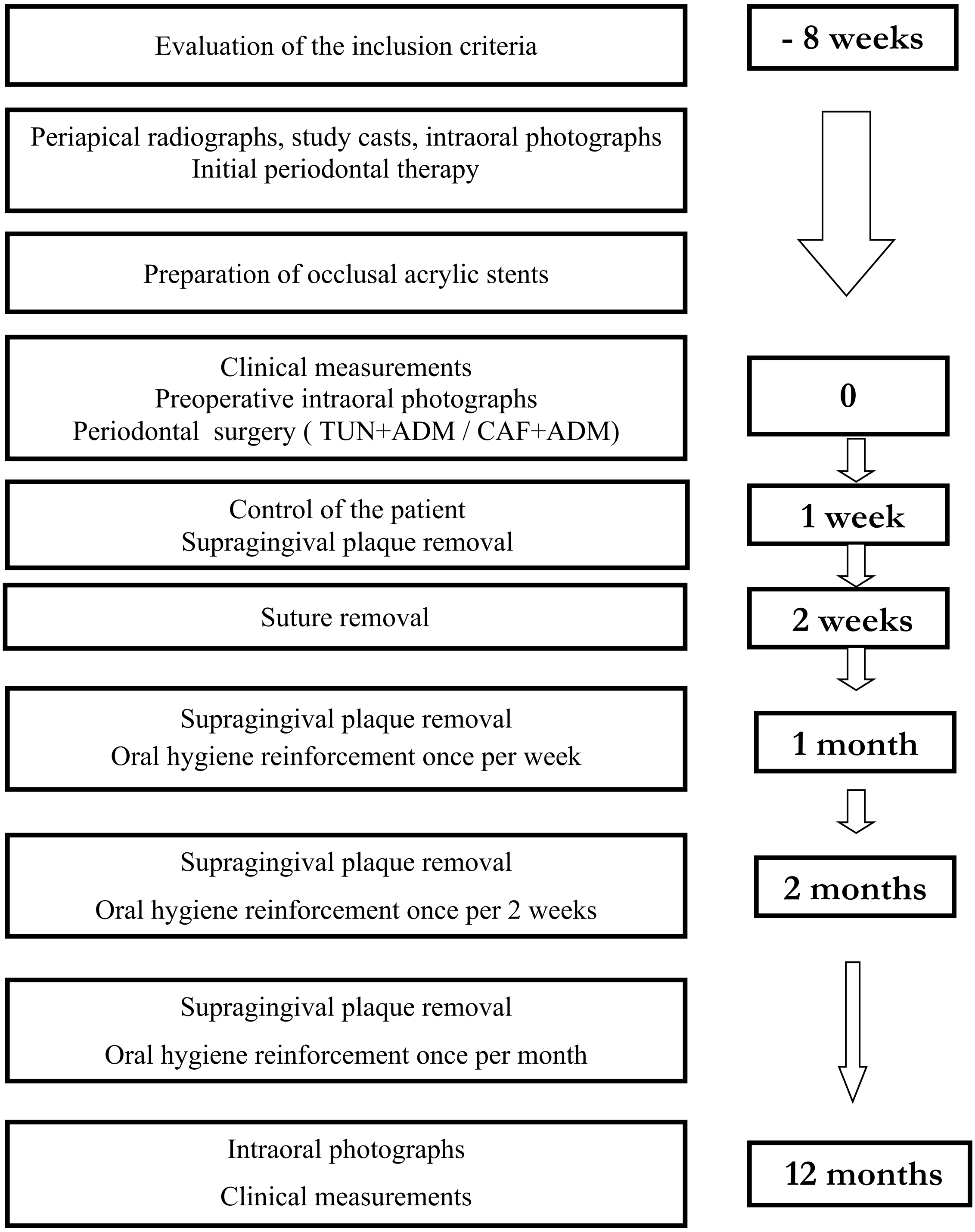

Figure 1. Study Design

3.4. Clinical Parameters and Measurements

All clinical measurements were performed by the same calibrated examiner at baseline and at 12 months after surgery. Before the start of the study, intra-examiner reproducibility was tested in 5 patients, not included in the study. The examiner performed measurements at least 6 anterior teeth in 5 patients on two occasions at 48 hours intervals. The examiner was accepted as calibrated if measurements at baseline and at 48 h were similar to the mm at ≥90%. Individually acrylic occlusal stents were used as the constant points in order to align the probe properly. Six vertical grooves were placed so that the baseline and the post-surgical measurements could be made at the same position and angulation. All measurements were taken with 0.4 mm diameter 15 mm calibrated periodontal probe[3] and measurements were rounded to the nearest 1 mm, except GT was measured with a digital calliper. All measurements were recorded in the personal data sheets prepared for the research (Figures 2, 3).

The following indices and measurements were used:

3.4.1. Plaque Index

Teeth were isolated by cotton rolls and after drying by air syringe, the microbial dental plaque on the teeth surfaces were evaluated by the explorer. Each gingival unit (mesio-buccal, mid-buccal, disto-buccal, mid-palatinal\lingual) of the tooth were given a score 0-3 (215).

The scores were recorded as follows:

0-No microbial dental plaque

1-A film of microbial dental plaque adhering to the free gingival margin and adjacent area of the tooth, recognized only after using the probe on the tooth surface.

2-Moderate accumulation of soft deposits within the gingival pocket, or on the tooth and gingival margin, which can be seen with the naked eye.

[3] **PCP 15 UNC**, Hu-Friedy, USA

3-Abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin.

3.4.2. Gingival Index

The periodontal probe was used to assess the bleeding potential of the tissues from 4 tooth surfaces (mesio-buccal papilla, mid-buccal margin, disto-buccal papilla, mid-palatinal\lingual margin) and scores between 0 – 3 were given for each point (216).

Scores were as follows:

0-Normal gingiva

1-Mild inflammation, slight change in color, slight edema; no bleeding on probing

2-Moderate inflammation, redness, edema, and glazing; bleeding on probing

3-Severe inflammation, marked redness and edema, ulceration; tendency to spontaneous bleeding

3.4.3. Bleeding on Probing (%)

The periodontal probe was used to assess bleeding on probing (BoP) from 4 tooth surfaces (mesio-buccal papilla, mid-buccal margin, disto-buccal papilla, mid-palatinal\lingual margin) and scored as positive (+) or negative (-) bleeding for each point (217).

3.4.4. Probing Depth (mm)

Probing depth of the recession defect was measured by the periodontal probe at the mid-buccal surface of the related tooth as the distance between the gingival margin and the bottom of the gingival sulcus (Figure 4).

3.4.5. Clinical Attachment Level (mm)

Clinical attachment level of the recession defect was defined as the distance between the cemento-enamel junction and the bottom of the gingival sulcus and was measured by the periodontal probe at the mid-buccal surface of the related tooth (Figure 4).

3.4.6. Recession Height (mm)

Recession height was measured from the cemento-enamel junction to the most apical point of the gingival margin at the mid-buccal surface of the related tooth by using a periodontal probe (Figure 4).

3.4.7. Recession Width (mm)

Recession width of the recession defect was measured at the level of cemento-enamel junction by the periodontal probe as the horizontal distance from one border of the gingival recession margin to another (Figure 4).

3.4.8. Keratinized Tissue Height (mm)

Keratinized tissue height of the recession defect was measured from the muco-gingival junction to the gingival margin by the periodontal probe at the mid-buccal surface of the related tooth (Figure 4).

3.4.9. Gingival Thickness (mm)

Gingival thickness was measured at the mid-buccal surface of the related tooth and at the mid-point location between the gingival margin and mucogingival junction, using a number 25 endodontic spreader[4] with a silicone disk stop. Under the local anaesthesia, the mucosal surface was pierced perpendicularly with slight pressure until hard tissue was reached. The silicone stop on the spreader was then slid until it was in close contact with the gingiva. After removal of the spreader, the distance between the tip of the spreader and the inner border of the silicone disk stop was measured with a digital calliper[5] (39) (Figure 4).

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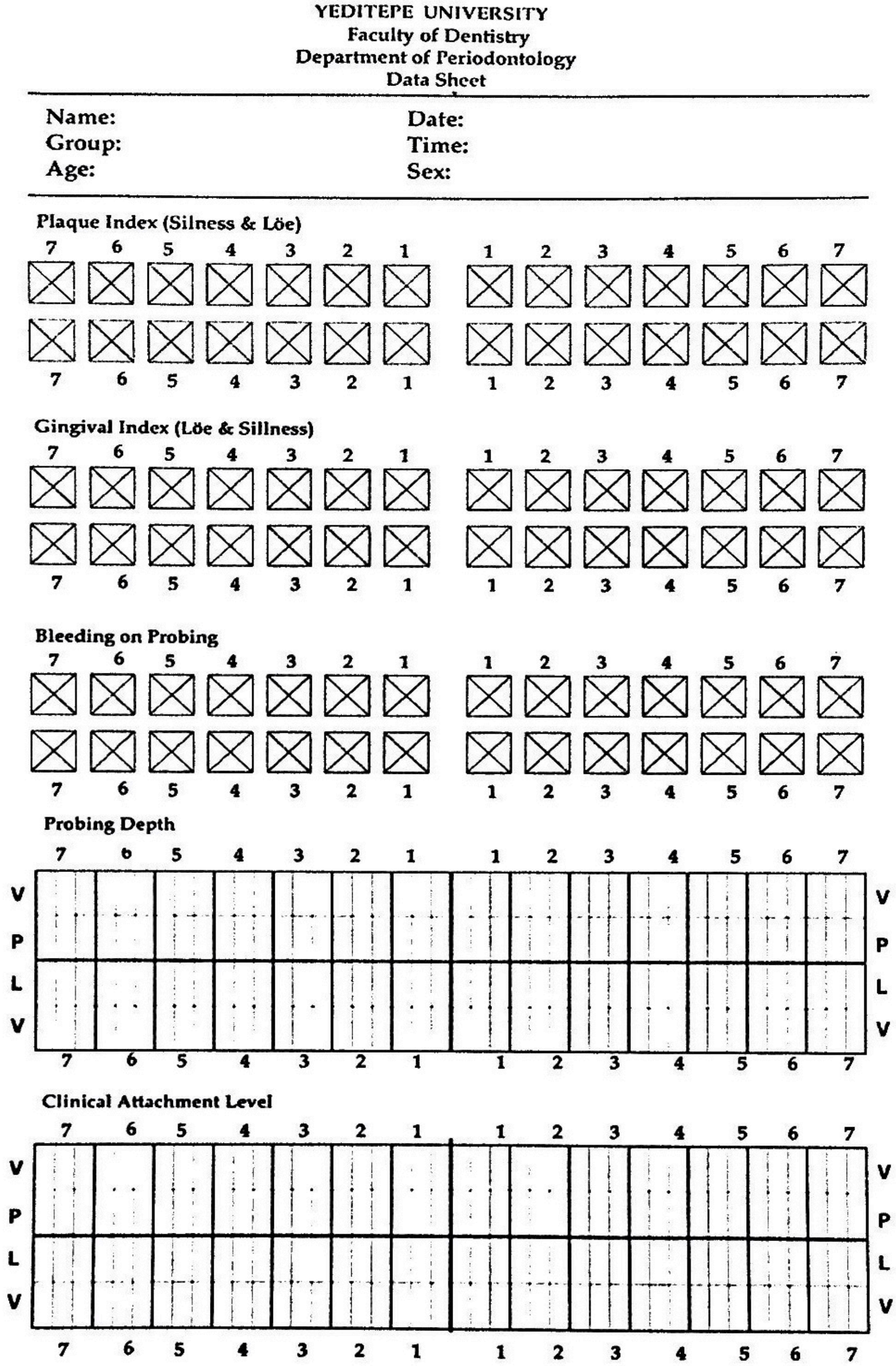
[4] **Endodontic Spreader #25**, MANI, JAPAN.
[5] **Stainless Steel Digital Caliper 75 mm,** SHAN, CHINA



YEDITEPE UNIVERSITY
Faculty of Dentistry
Department of Periodontology
Data Sheet

Name: | Date:
Group: | Time:
Age: | Sex:

Plaque Index (Silness & Löe)
7 6 5 4 3 2 1 1 2 3 4 5 6 7
7 6 5 4 3 2 1 1 2 3 4 5 6 7

Gingival Index (Löe & Sillness)
7 6 5 4 3 2 1 1 2 3 4 5 6 7
7 6 5 4 3 2 1 1 2 3 4 5 6 7

Bleeding on Probing
7 6 5 4 3 2 1 1 2 3 4 5 6 7
7 6 5 4 3 2 1 1 2 3 4 5 6 7

Probing Depth
7 6 5 4 3 2 1 1 2 3 4 5 6 7
V P L V | V P L V
7 6 5 4 3 2 1 1 2 3 4 5 6 7

Clinical Attachment Level
7 6 5 4 3 2 1 1 2 3 4 5 6 7
V P L V | V P L V
7 6 5 4 3 2 1 1 2 3 4 5 6 7

Figure 2. Data Sheet 1

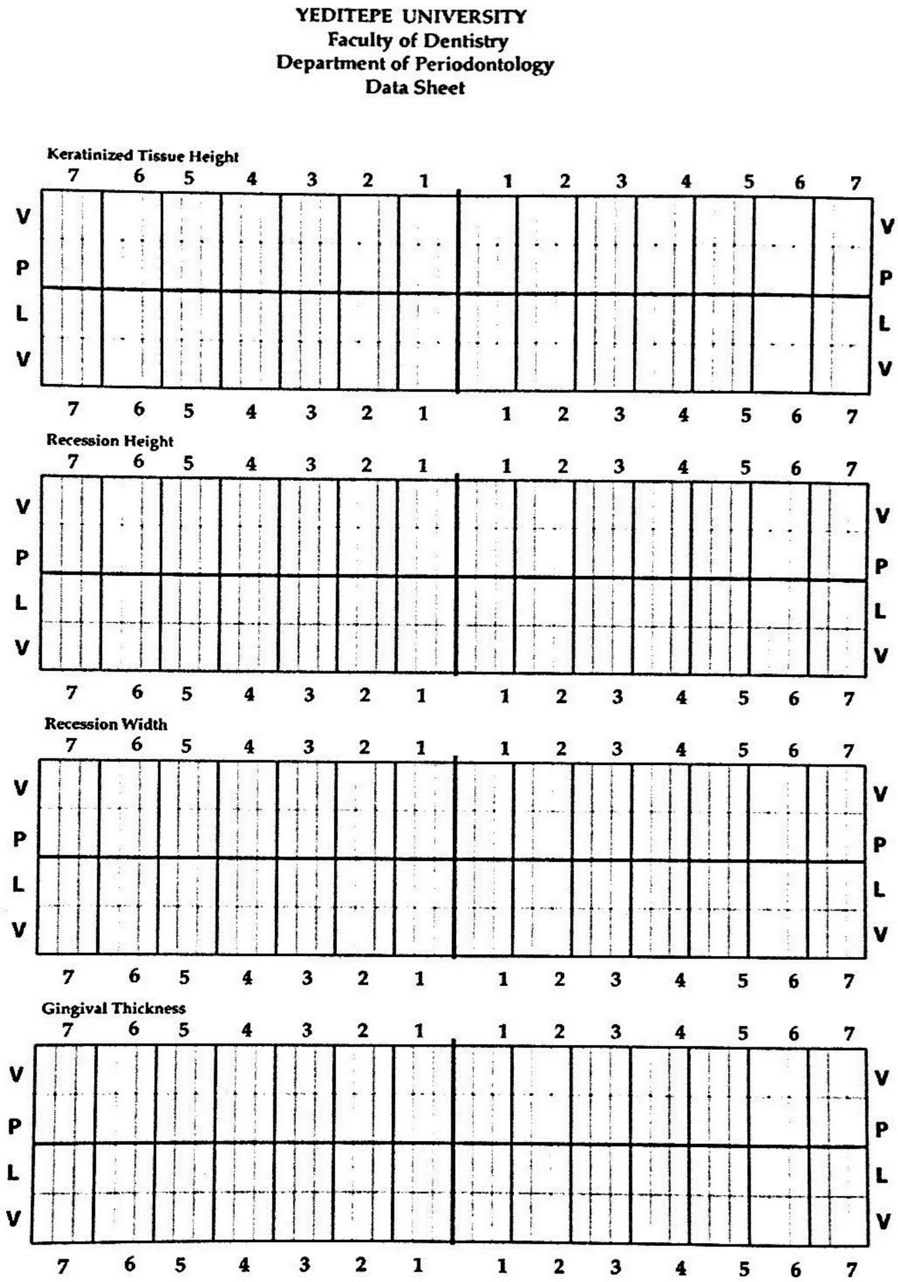
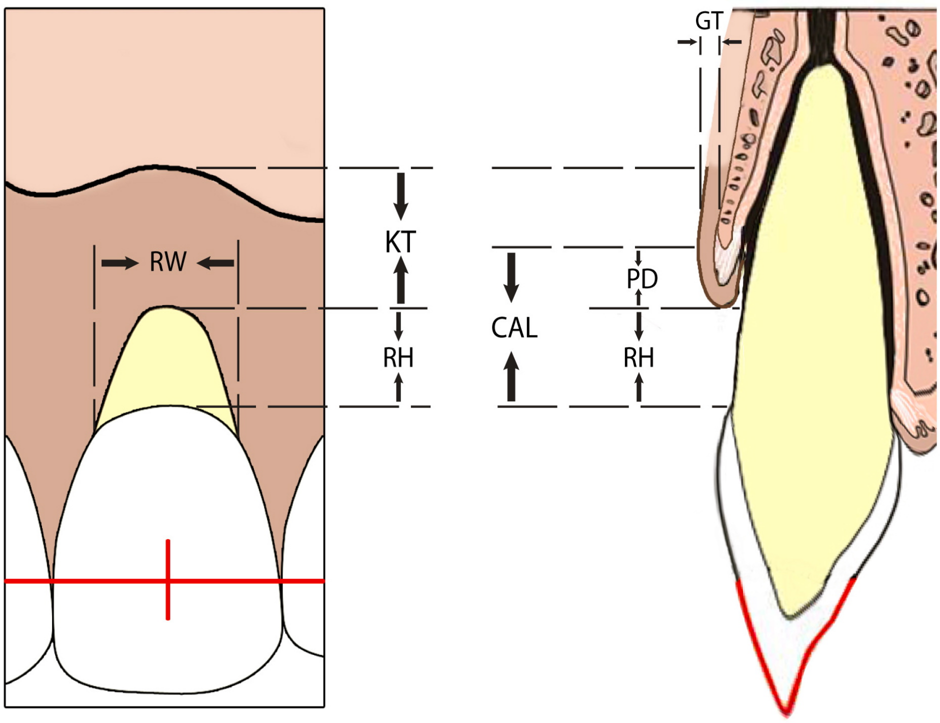


Figure 3. Data Sheet 2



PD	Probing Depth
CAL	Clinical Attachment Level
RH	Recession Height
RW	Recession Width
KT	Keratinized Tissue
GT	Gingival Thickness

Figure 4. Schematic drawing of clinical measurements.

3.4.10. Defect Coverage

Mean root coverage (%) was calculated at patient level as follows:
[(RH baseline – RH 12 months)/RH baseline] x 100

Complete root coverage (%) was evaluated at tooth level. Complete root coverage was calculated as the percentage of teeth with defects having complete coverage achieved as the gingival margin at cemento-enamel junction or coronal level (105).

Percentage of CRC was calculated as follows:
[(Teeth with complete root coverage) / (All treated teeth)] × 100 %

3.4.11. Patient Satisfaction Score

Patient satisfaction was assessed using a three-point rating scale and patients were questioned with regard to the following patient-centered criteria: Root coverage attained, relief from dentinal hypersensitivity, colour of gums, shape and contour of gums, surgical procedure in terms of pain during surgery and the discomfort experienced related to the duration of the procedure and handling by the operator, post surgical phase in terms of pain, swelling, and postoperative complications; and cost effectiveness in terms of the time and money spent for the treatment (47). Three represents fully satisfied; 2 satisfied; and 1 unsatisfied.

3.4.12. Root Coverage Esthetic Score

Aesthetic outcomes of the root coverage procedures was assed by using a scoring system called root coverage esthetic score (RES) (155). Gingival margin level, marginal tissue contour, soft tissue texture, mucogingival junction alignment and gingival colour were evaluated. Zero, 3 and 6 points were used for the evaluation of the position of the gingival margin, whereas a score 0 or 1 point was used for each of the other variables. The ideal score was 10. If the final position of gingival margin was equal or apical to the previous recession depth (failure of root coverage procedure), irrespective of colour, the presence of scar, marginal tissue contour, or mucogingival junction, or a partial or total loss of interproximal papilla (black triangle) occurred following the treatment, 0 points was assigned.

Table 1. RES variables and definitions.

Gingival Margin Level	**0**	Failure of root coverage (Gingival margin apical or equal to the baseline recession)
	3	Partial root coverage
	6	CRC
Marginal Tissue Contour	**0**	Irregular gingival margin (Does not follow cemento-enamel junction)
	1	Proper marginal contour/scalloped gingival margin (Follows cemento-enamel junction)
Soft Tissue Texture	**0**	Scar formation and/or keloid like appearance
	1	Absence of scar or keloid formation
Mucogingival Junction Alignment	**0**	Mucogingival junction not aligned with the junction of adjacent teeth
	1	Mucogingival junction aligned with the junction of adjacent teeth
Gingival Colour	**0**	Colour of tissues varies from gingival colours at adjacent teeth
	1	Normal colour and integration with the adjacent soft tissues

3.5. Acellular Dermal Matrix Graft Preparation Protocol

Acellular dermal matrix graft[6] (Figure 5) was prepared according to the manufacturer's instructions. The allograft was rehydrated aseptically in the sterile saline for 10 minutes (Figure 6). Then the material was removed and used for the procedure.

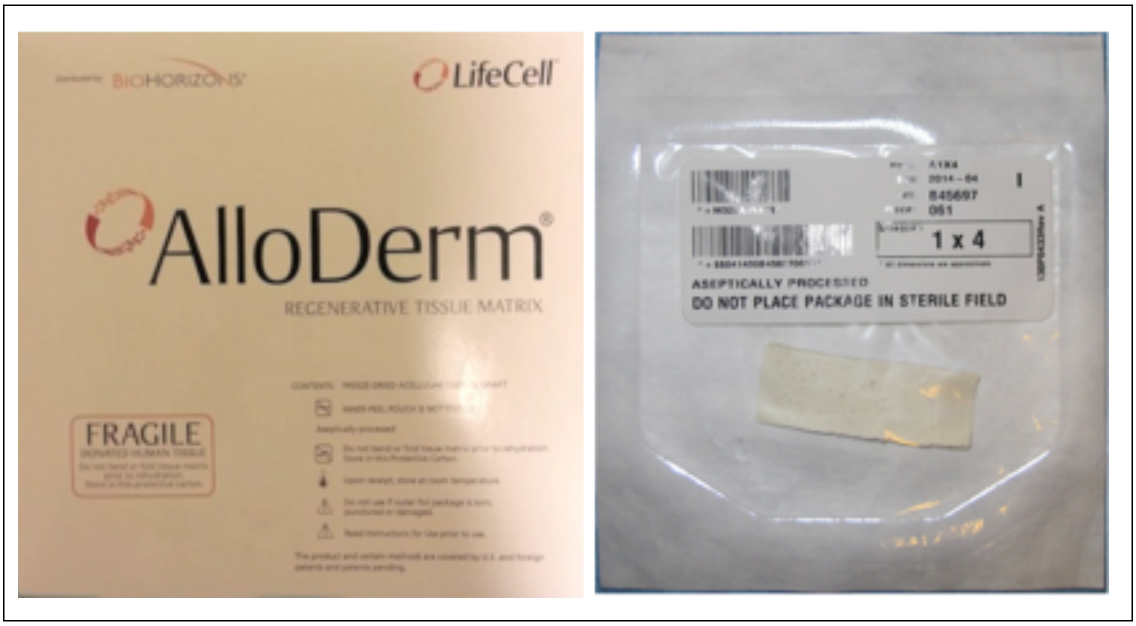


Figure 5. ADM graft

[6] **AlloDerm® Regenerative Tissue Matrix**, BioHorizons, USA

Figure 6. ADM rehydration procedure

3.6. Surgical Procedure

The surgical procedure in TUN+ADM group was based on the tunnel procedure without any vertical releasing incisions and ADM is then placed and secured through this tunnel. After local anesthesia[7], root planing of the exposed root surface was performed. An intra-sulcular incision was made through each recession area by using 15C blade[8] without damaging interdental papilla. During the surgery, tunnel instruments were used (Figure 7). The full thickness flap dissection was made with a tunnel elevator instrument[9] and extended under each papilla till the mucogingival junction. Then the split thickness dissection was performed far beyond the mucogingival junction so that the flap could be moved in a coronal direction without tension and also there is enough relaxation for the entrance of the graft underneath. Muscle fibers and any remaining collagen bundles on the inner aspect of the flap alveolar mucosa were separated with extreme care to obtain a passive coronal positioning of the flap. The tunnel was extended 3 to 5 mm mesial and distal from the lateral teeth to allow space for the

[7] **Ultracain DS Fort 2 ml** , Aventis Pharma Turkey, Turkey
[8] **Scalpel Blade 15C, Braun, Aesculap,** Germany
[9] **Tunneling Knife #1, #2, Hu-Friedy,** USA

seating of the mesial and distal aspects of the ADM. For placing the graft into the tunnel, a suture was placed at the distal aspect of the graft. Acellular dermal matrix graft was placed through the tunnel from the most mesial recession site, than suture needle was passed underneath the tunnel and the graft was slide through the tunnel. The ADM was positioned at the cemento-enamel junction level and extended approximately 3 mm beyond the osseous defect margins. The flap margin was positioned coronal to the cemento-enamel junction to completely cover the defect and ADM, and sutured with double sling suture technique with 5-0 non-resorbable polypropylene monofilament sutures[10]. Mild compression with sterile gauze with saline was performed for 5 minutes before completing the surgical procedure to achieve homeostasis and a close adaptation of the flap to the underlying surface. No surgical dressing was used for both treatment groups. All the surgical procedures were documented with clinical photographs.

In CAF+ADM group following local anaesthesia, trapezoidal flap was designed. An intra-sulcular incision was made at the buccal aspect of the involved teeth with 15C blade. Horizontal incisions were made at the interproximal cemento-enamel junction level of the interdental papillae, without interfering with the gingival margin of the neighbouring teeth. Two vertical incisions were made at the distal ends of the horizontal incisions, across the mucogingival line and reaching the alveolar mucosa. Releasing incisions beyond the mucogingival junction was made to allow for a tension-free coronal repositioning of the flap. A split-full-split thickness flap was elevated to expose at least 3 mm of the marginal bone apical to the dehiscence area. Papilla was deepithelialized for better vascularization of the tissue bed. The root planing of exposed surface was performed with hand instruments. After that ADM was placed over the root surface to the level of cemento-enamel junction, exposed root surface and also at least 3 mm surrounding bone was covered with the graft. The basement membrane side was placed adjacent to bone and tooth, and the connective tissue side was placed facing the flap. Acellular dermal matrix graft was stabilized by using double sling suture technique with 5–0 resorbable polyglyconate monofilament sutures[11]. The flap was coronally positioned at the level of coronal to cemento-enamel junction and sutured to completely cover the ADM using double sling suture technique with 5–0 non-resorbable

[10] **Propilen 5-0 sutures, dogsan,** Turkey
[11] **Pegelak, 5-0 sutures, dogsan,** Turkey

polypropylene monofilament sutures. The releasing incisions were closed with interrupted sutures. Mild compression was applied before completing the procedure.

Figure 7. Tunnel Instruments

3.7. Post-Surgical Medication and Care

Written and oral postoperative instructions were given to the patients in order to the maintenance of wound stability, pain and infection control. The patients received postoperative systemic antibiotic therapy for a period of 7 days (2x1000 mg, amoxicillin clavulanate, 7 days)[12]. Oral analgesics (3X550 mg, naproxen sodium, 3 days)[13] and oral

[12] **Augmentin BID 1000 mg**; GlaxoSmithKline Pharmaceuticals Turkey, Turkey

rinse (0,2% solution of chlorhexidine glukonate)[14] were also prescribed. Patients were informed not to brush their teeth and avoid hard chewing in the operated areas until suture removal and they were instructed to rinse their mouths with chlorhexidine solution twice a day for one minute for 4 weeks.

After a healing period of 2 weeks, sutures were removed and all patients were seen weekly for 1 month. Four weeks 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. Then all patients were recalled once per 2 weeks for 2 months, and once a month until the end of the study. Post-operative visits consisted of supragingival plaque removal, tooth polishing and oral hygiene reinforcement. At the end of the 12-month evaluation period all baseline clinical measurements and photographs were repeated.

3.8. Data Analysis

The statistical analysis was performed using commercially available software[15]. A subject-level analysis was performed for each parameter except CRC. Mean values and standard deviations (mean ± SD) for the clinical parameters were calculated. Data analysis was done for full mouth for PI, GI and BoP, whereas defect site measurements were used for PD, CAL, RH, GT and KT. All the parameters were measured at baseline and 12 months after the surgery. The balancing of groups by age and gender was tested by Student's t-test and Fisher's Exact test, respectively. Parameters with normal distribution for the comparison of quantitative data were evaluated using Student's t-test and Paired Sample t test, whereas parameters, which did not have a normal distribution, were evaluated using Mann Whitney U-test and Wilcoxon sign test. The Paired Sample t and Wilcoxon sign tests were used to evaluate the intragroup differences, whereas the Student's t and Mann-Whitney U tests were used to evaluate the intergroup differences. Power calculations were based on data from previous study (213). For the sample size

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[13] **Apranax Forte Tablets 550 mg**; Abdi Ibrahim, Turkey
[14] **Klorhex Oral Rinse % 0,2;** Drogsan Pharmaceuticals, Turkey
[15] **IBM SPSS Statistics 22**, USA

calculation defect coverage was used as the primary outcome variable According to the results of power analysis, the sample size of 9 subjects for each group were defined for 80 % statistical power $\beta=0.20$ and $\alpha=0.05$ to detect $\Delta=1$, standard deviation (SD): 0.7. The value of $p<0.05$ was considered as the level of significance.

4. RESULTS

4.1. Demographic Results and Recession Location

Twenty patients aged between 22-42 years (mean age of 30.70 ± 5.94) with 58 Miller I buccal gingival recession defects ≥3 mm met the selection criteria were participated in this study. The recessions were located in 22 incisors, 15 canines and 21 premolars. Age and gender of the patients, and recession location are presented in Tables 2 & 3, respectively.

Table 2. Age and gender distribution of the patients

		TUN + ADM	**CAF + ADM**	***P***
Age		32.80 ± 6.71	28.60 ± 4.42	0.116 $^{+}$
Gender	**Male**	3 (30%)	4 (40%)	1.000 $^{++}$
	Female	7 (70%)	6 (60%)	

$^{+}$ Student's t-test, $^{++}$ Fisher`s Exact Test, p<0.05.

Table 3. Location of the recession defects

TUN + ADM	**Incisors**	**Canines**	**Premolars**
Maxilla	5	4	5
Mandible	7	4	6
CAF + ADM	**Incisors**	**Canines**	**Premolars**
Maxilla	4	4	6
Mandible	6	3	4

4.2. Clinical Results

All patients completed the study and none of them was excluded from the study. Healing was uneventful in all patients and one representative case from each group was documented in Figures 8.a-f and 9.a-f.

4.2.1. Baseline Parameters

No statistically significant differences were observed between the groups at baseline in terms of all evaluated parameters ($p>0.05$) (Table 4).

Table 4. Comparison of baseline parameters in TUN+ADM and CAF+ADM groups

	TUN + ADM Mean±SD (Median)	**CAF + ADM Mean±SD (Median)**	***P***
PI	0.50 ± 0.04	0.47 ± 0.09	0.313^{+}
GI	0.51 ± 0.02	0.51 ± 0.09	0.847^{+}
BoP (%)	9.00 ± 0.62 (8.85)	8.80 ± 1.31(9)	0.879^{++}
PD (mm)	1.15 ± 0.25 (1)	1.10 ± 0.21 (1)	0.618^{++}
CAL (mm)	4.33 ± 0.35 (4.3)	4.40 ± 0.46 (4.25)	0.842^{++}
RH (mm)	3.23 ± 0.28 (3.14)	3.30 ± 0.35 (3.25)	0.712^{++}
RW (mm)	3.21 ± 0.50 (3.37)	3.50 ± 0.53 (3.5)	0.175^{++}
GT (mm)	0.82 ± 0.06 (0.82)	0.76 ± 0.06 (0.72)	0.055^{++}
KT (mm)	2.34 ± 0.66 (2.1)	2.47 ± 0.51 (2.5)	0.563^{++}

$^{+}$ Student's t-test, $^{++}$ Mann Whitney U test, $p<0.05$.

4.2.2. Plaque Index

The mean values and standard deviations of PI scores at baseline and after 12 months, and intra-group comparisons are presented in Table 5. Intra-group comparisons revealed statistically significant differences in PI values in both groups at 12 months ($p<0.05$). Inter-group difference was not statistically significant for PI scores (Table 14, $p>0.05$).

Table 5. Mean values and standard deviations of PI at baseline and 12 months after treatment, and intra-group comparisons

		TUN+ADM Mean±SD	**CAF+ADM Mean±SD**	^{+}p
PI	**Baseline**	0.50 ± 0.04	0.47 ± 0.09	**0.313**
	12 months	0.43 ± 0.04	0.42 ± 0.09	**0.596**
	^{++}p	**0.001**	**0.001**	

$^{+}$Student's t-test, $^{++}$Paired Sample t-test, $p<0.05$.

4.2.3. Gingival Index

The mean values and standard deviations of GI scores at baseline and after 12 months, and intra-group comparisons are presented in Table 6. Intra-group comparisons revealed statistically significant differences in GI values in both groups at 12 months ($p<0.05$). Inter-group difference was not statistically significant for GI values (Table 14, $p>0.05$).

Table 6. Mean values and standard deviations of GI at baseline and 12 months after treatment, and intra-group comparisons

		TUN+ADM Mean±SD	CAF+ADM Mean±SD	^{+}p
GI	**Baseline**	0.51 ± 0.02	0.51 ± 0.09	**0.847**
	12 months	0.48 ± 0.03	0.45 ± 0.09	**0.311**
	^{++}p	**0.001**	**0.005**	

$^{+}$Student's t-test, $^{++}$Paired Sample t-test, $p<0.05$.

4.2.4. Bleeding on Probing (%)

The mean values and standard deviations of BoP scores at baseline and after 12 months, and intra-group comparisons are presented in Table 7. Intra-group comparisons revealed statistically significant differences in BoP values in both groups at 12 months ($p<0.05$). Inter-group difference was not statistically significant for BoP scores (Table 14, $p>0.05$).

Table 7. Mean values and standard deviations of BoP at baseline and 12 months after treatment, and intra-group comparisons.

		TUN+ADM Mean±SD (Median)	CAF+ADM Mean±SD (Median)	^{+}p
BoP (%)	**Baseline**	9.00 ± 0.62 (8.85)	8.80 ± 1.31 (9)	**0.879**
	12 months	8.06 ± 0.32 (8)	7.80 ± 1.55 (8)	**0.939**
	^{++}p	**0.005**	**0.026**	

$^{+}$Mann Whitney U test, $^{++}$Wilcoxon sign test, $p<0.05$.

5.2.5. Probing Depth (mm)

The mean values and standard deviations of PD measurements at baseline and after 12 months, and intra-group comparisons are presented in Table 8. There was a statistically significant increase in PD measurements in CAF+ADM group at 12 months ($p<0.05$), however the increase was not statistically significant in TUN+ADM group ($p>0.05$). Inter-group difference was not statistically significant for PD (Table 14, $p>0.05$).

Table 8. Mean values and standard deviations of PD measurements at baseline and 12 months after treatment, and intra-group comparisons

		TUN+ADM Mean±SD (Median)	CAF+ADM Mean±SD (Median)	^{+}p
PD (mm)	**Baseline**	1.15 ± 0.25 (1)	1.10 ± 0.21 (1)	**0.618**
	12 months	1.21 ± 0.23 (1.14)	1.45 ± 0.44 (1.5)	**0.212**
	^{++}p	**0.496**	**0.020**	

$^{+}$Mann Whitney U test, $^{++}$Wilcoxon sign test, $p<0.05$.

4.2.6. Clinical Attachment Level (mm)

The mean values and standard deviations of CAL measurements at baseline and after 12 months, and intra-group comparisons are presented in Table 9. There was a statistically significant decrease in CAL measurements, revealing attachment gain, in both groups at 12 months ($p<0.05$). Inter-group comparisons revealed statistically significant differences for attachment gain in favor of CAF+ADM group (Table 14, $p<0.05$).

Table 9. Mean values and standard deviations of CAL measurements at baseline and 12 months after treatment, and intra-group comparisons

		TUN+ADM Mean±SD (Median)	**CAF+ADM Mean±SD (Median)**	^{+}p
CAL (mm)	**Baseline**	4.33 ± 0.35 (4.3)	4.40 ± 0.46 (4.25)	**0.842**
	12 months	2.00 ± 0.33 (2)	1.65 ± 0.71 (1.5)	**0.145**
	^{++}p	**0.005**	**0.004**	

$^{+}$Mann Whitney U test, $^{++}$Wilcoxon sign test, $p<0.05$.

4.2.7. Recession Height (mm)

The mean values and standard deviations of RH at baseline and after 12 months, and intra-group comparisons are presented in Table 10. Intra-group comparisons for RH revealed statistically significant differences in both groups at 12 months (Table 10, $p<0.05$). Inter-group comparison for RH reduction was statistically significant in favor of CAF+ADM group (Table 14, $p<0.05$). Recession height reduction was 2.45 ± 0.20 mm and 3.10 ± 0.57 mm in TUN+ADM and CAF+ADM groups at 12 months, respectively.

Table 10. Mean values and standard deviations of RH measurements at baseline and 12 months after treatment, and intra-group comparisons

		TUN+ADM Mean±SD (Median)	**CAF+ADM Mean±SD (Median)**	^{+}p
RH (mm)	**Baseline**	3.23 ± 0.28 (3.14)	3.30 ± 0.35 (3.25)	**0.712**
	12 months	0.79 ± 0.26 (0.7)	0.20 ± 0.42 (0)	**0.006**
	^{++}p	**0.005**	**0.005**	

$^{+}$Mann Whitney U test, $^{++}$Wilcoxon sign test, $p<0.05$.

4.2.8. Recession Width (mm)

The mean values and standard deviations of RW at baseline and after 12 months, and intra-group comparisons are presented in Table 11. Intra-group comparisons revealed statistically significant differences for RW in both groups at 12 months (Table 11, $p<0.05$). Inter-group comparison for RW reduction was statistically significant in favor of CAF+ADM group (Table 14, $p<0.05$). Recession width reduction was 1.83 ± 0.60 mm and 3.10 ± 0.87 mm in TUN+ADM and CAF+ADM groups at 12 months, respectively.

Table 11. Mean values and standard deviations of RW measurements at baseline and 12 months after treatment, and intra-group comparisons

		TUN+ADM Mean±SD (Median)	**CAF+ADM Mean±SD (Median)**	^{+}p
RW (mm)	**Baseline**	3.21 ± 0.50 (3.37)	3.50 ± 0.53 (3.5)	**0.175**
	12 months	1.38 ± 0.51 (1.37)	0.40 ± 0.84 (0)	**0.010**
	^{++}p	**0.005**	**0.005**	

$^{+}$Mann Whitney U test, $^{++}$Wilcoxon sign test, $p<0.05$.

4.2.9. Keratinized Tissue Height (mm)

The mean values and standard deviations of KT at baseline and after 12 months, and intra-group comparisons are presented in Table 12. Intra-group comparisons revealed statistically significant differences for KT in both groups at 12 months (Table 12, $p<0.05$). Inter-group comparison for KT increase was statistically significant in favor of CAF+ADM group (Table 14, $p<0.05$). Keratinized tissue increase was 0.87 ± 0.42mm and 1.25 ± 0.24 mm in TUN+ADM and CAF+ADM groups at 12 months, respectively.

Table 12. Mean values and standard deviations of KT measurements at baseline and 12 months after treatment, and intra-group comparisons

		TUN+ADM Mean±SD (Median)	CAF+ADM Mean±SD (Median)	^{+}p
KT (mm)	**Baseline**	2.34 ± 0.66 (2.1)	2.47 ± 0.51 (2.5)	**0.563**
	12 months	3.21 ± 0.57 (3)	3.72 ± 0.55 (3.8)	**0.044**
	^{++}p	**0.005**	**0.004**	

$^{+}$Mann Whitney U test, $^{++}$Wilcoxon sign test, $p<0.05$.

4.2.10. Gingival Thickness (mm)

The mean values and standard deviations of GT at baseline and after 12 months, and intra-group comparisons are presented in Table 13. Intra-group comparisons revealed statistically significant increase in GT values in both groups at 12 months ($p<0.05$). No statistically significant difference was observed between the groups in terms of GT increase (Table 14, $p>0.05$).

Table 13. Mean values and standard deviations of GT measurements at baseline and 12 months after treatment, and intra-group comparisons

		TUN+ADM Mean±SD (Median)	CAF+ADM Mean±SD (Median)	^{+}p
GT (mm)	**Baseline**	0.82 ± 0.06 (0.82)	0.76 ± 0.06 (0.72)	**0.055**
	12 months	1.40 ± 0.07 (1.41)	1.38 ± 0.09 (1.35)	**0.511**
	^{++}p	**0.005**	**0.005**	

$^{+}$Mann Whitney U test, $^{++}$Wilcoxon sign test, $p<0.05$.

4.2.11. Inter-group Comparisons of Clinical Parameters

Inter-group comparisons of all measurements at 12 months after treatment are presented in Table 14. Inter-group differences were found to be statistically significant for RH and RW reduction, KT increase and attachment gain ($p<0.05$), and not significant for PI, GI, BoP, PD change and GT increase ($p>0.05$).

Table 14. Inter-group comparisons of all measurements at 12 months after treatment

	TUN+ADM Mean±SD (Median)	**CAF+ADM Mean±SD (Median)**	$^{+}$***p***
PI	0.07 ± 0.03 (0,08)	0.05 ± 0.04 (0.05)	**0.110**
GI	0.04 ± 0.01 (0.04)	0.06 ± 0.04 (0.04)	**0.433**
BoP (%)	0.94 ± 0.65 (0.75)	1.00 ± 1.05 (1)	**0.939**
PD Change (mm)	-0.06 ± 0.29 (0)	-0.35 ± 0.34 (-0.5)	**0.062**
Attachment Gain (mm)	2.33 ± 0.42 (2.46)	2.75 ± 0.59 (3)	**0.043**
RH Reduction (mm)	2.45 ± 0.20 (2.5)	3.10 ± 0.57 (3)	**0.006**
RW Reduction (mm)	1.83 ± 0.60 (2)	3.10 ± 0.87 (3.25)	**0.005**
GT Gain (mm)	0.58 ± 0.07 (0.57)	0.62 ± 0.10 (0.6)	**0.296**
KT Gain (mm)	0.87 ± 0.42 (1)	1.25 ± 0.24 (1.25)	**0.027**

$^{+}$Mann Whitney U test, $p<0.05$.

4.2.12. Defect Coverage (%)

Mean root coverage, and CRC in both groups are presented in Tables 15 & 16. Mean root coverage was 75.72 % in TUN+ADM group, whereas 93.81 % in CAF+ADM group. At 12 months, CRC was obtained in 12 out of 31 recessions (37.36%) with TUN+ADM approach, whereas in 23 out of 27 recessions (85%) with CAF+ADM. Inter-group comparisons revealed statistically significant differences for MRC and CRC in favor of the CAF+ADM group ($p<0.05$).

Tablo 15. Inter-group comparison of MRC at patient level

	Mean Defect Coverage (%) **Mean±SD** **(Median)**	^{+}p
TUN+ADM	75.72 ± 6.54 (76.5)	**0.005**
CAF+ADM	93.81 ± 13.10 (100)	

$^{+}$Mann Whitney U test, $p<0.05$.

Tablo 16. Inter-group comparison of CRC at tooth level

	Complete Root Coverage (%) **Mean±SD** **(Median)**		^{+}p
TUN+ADM	12 / 31	37.36 ± 21.10 (50)	**0.003**
CAF+ADM	23 / 27	85.00 ± 33.75 (100)	

$^{+}$Mann Whitney U test, $p<0.05$.

4.2.13 Patient Satisfaction Score

Inter-group comparisons of overall patient satisfaction scores at 12 months after treatment are presented in Table 17. Inter-group comparisons revealed that overall patient satisfaction was similar in both groups ($p>0.05$).

Table 17. Inter-group comparison of patient satisfaction scores

	Patient Satisfaction Score **Mean±SD** **(Median)**	^{+}p
TUN+ADM	17.10 ± 1.66 (18)	**0.094**
CAF+ADM	18.50 ± 1.71 (18.5)	

$^{+}$Mann Whitney U test, $p<0.05$.

4.2.14. Root Coverage Esthetic Score

The results of RES at 12 months in both groups are presented in Table 18. Root coverage esthetic score was significantly higher in CAF+ADM group ($p<0.05$).

Table 18. Inter-group comparison of RES

	RES Mean±SD (Median)	^{+}p
TUN+ADM	7.30 ± 1.25 (7)	**0.034**
CAF+ADM	8.90 ± 1.60 (10)	

$^{+}$Mann Whitney U test, $p<0.05$

Figure 8a. TUN+ADM group, Preoperative view

Figure 8b. Flap elevation

Figure 8c. Tunnel preparation.

Figure 8d. ADM placed into the tunnel.

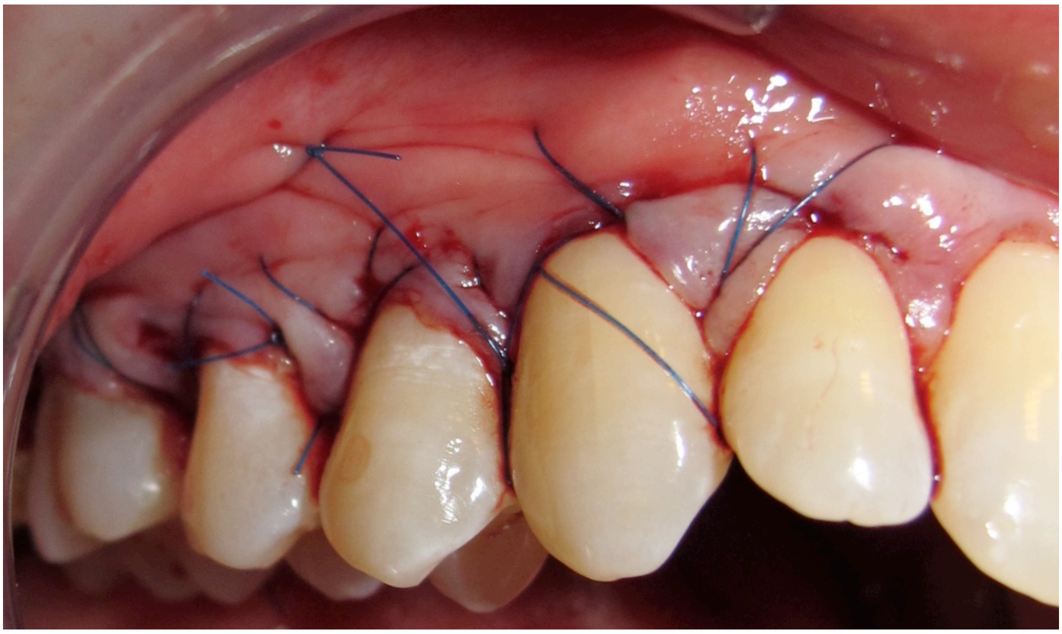

Figure 8e. Suturing with 5-0 non-resorbable sutures.

Figure 8f. Postoperative view at 12 months

Figure 9a. CAF+ADM group, Preoperative view.

Figure 9b. Flap design and incisions.

Figure 9c. Flap elevation.

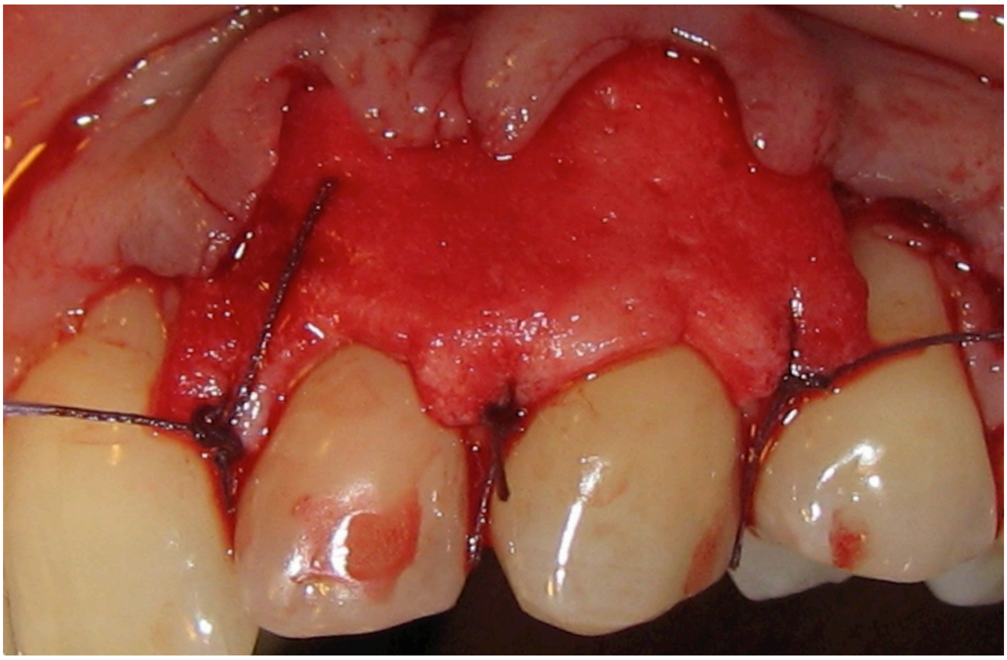

Figure 9d. ADM stabilization with 5-0 resorbable sutures.

Figure 9e. Suturing with 5-0 non-resorbable sutures.

Figure 9f. Postoperative view at 12 months.

5. DISCUSSION

The primary aim of this randomized, controlled, parallel clinical study was to evaluate clinical effectiveness of ADM in combination with TUN on defect coverage, aesthetics and patient satisfaction compared to CAF+ADM for the treatment of multiple gingival recessions. The mean root coverage obtained at 12 months was 75.72% and 93.81% in TUN+ADM and CAF+ADM, respectively ($p<0.05$). Complete defect coverage was achieved 37.36% of the teeth (12 out of 31 sites) for the TUN+ADM group, while it occurred 85% of the teeth (23 out of 27 sites) for the CAF+ADM group. Significantly better clinical improvements and aesthetical results were achieved with CAF+ADM graft combination ($p<0.05$).

In this study we aim to compare TUN+ADM with CAF+ADM. In a recent systematic review (8) evaluating the efficacy of periodontal plastic procedures in the treatment of multiple gingival recessions, CAF and TUN were reported as the techniques that have higher level of CRC and the authors suggest that the probability of being the best treatment in terms of RH reduction are associated with the usage of CAF and a grafting procedure, such as ADM (8). Therefore in the present study we decided to use ADM as a graft material. Although the evidence in the published literature has shown that the combined procedure with the additional use of CTG is the most effective and predictable surgical approach for covering gingival recession defects, CTG harvesting often results increasing patient morbidity associated with the second surgical site, prolonged surgical time, and possibility of postoperative complications (palatal necrosis, pain and bleeding) (84,115,218). Especially in the treatment of multiple gingival recessions it is difficult to obtain sufficient donor tissue. Furthermore shallow or thin palate might be a problem for the clinician. To overcome these problems ADM has been used in this study as a successful alternative to CTG with decreased complications, unlimited donor tissue, good color compatibility (45,47,52–54,56,58,89,179). Acellular dermal matrix graft combined with CAF procedure repeatedly shown to work as well as CTG in terms of predictability, MRC and GT increase (32,35,37,38,45,46,53,58,175,177,213). Histologically, the healing process of ADM and CTG grafts is similar, with the similar amount of long junctional epithelial attachment and connective tissue attachment (45,177,183,213).

As a technique TUN is compared to CAF. The TUN proposed as a safe and predictable technique in the treatment of multiple gingival recessions with several advantages such as; it avoids vertical incisions, and the papilla was kept intact (8,85,108). The flap design may improve vascularization of the area, which may lead to quick healing, less scarring, better aesthetics and minimal postoperative complications (91,92,94,95,97–99,107,108,214). Also, due to coronal displacement of the flap, the graft material can be completely covered, thus ADM which works best when completely covered, could be used as a graft material. The TUN+ADM procedure is a minimally invasive surgical technique that does not require a donor site, which greatly minimized the amount of surgical trauma (106,109–112). Multiple gingival recessions, affecting aesthetic areas of the mouth, were successfully treated with TUN (106,109–112), therefore in this study TUN+ADM was used to treat multiple gingival recessions and compared to CAF+ADM, as the control procedure. Considering the beneficial aspects of the TUN, we could have expected more improvements than the results obtained in this study in terms of root coverage, but both MRC and CRC was better in CAF+ADM group. These findings are similar with previous studies reported in the literature about the use of ADM graft in combination with TUN and compared to CAF (106,110,111).

Recent evidence indicates that CAF as an effective surgical procedure for the treatment of multiple gingival recessions in terms of MRC, aesthetics and long-term stability (5,10,11,54,58,172). Optimum root coverage results, good color blending of soft tissues, and aesthetic results can be predictably accomplished using this surgical approach (38,39,50,53,54,58,89,144,195). Previous reports exhibited successful defect coverage with CAF+ADM approach in the treatment of multiple gingival recessions (8). The results obtained in this study are in accordance with the previous results that obtained with CAF+ADM approach (38,42,45,47,56,58,110,111,213).

Several reviews suggested that Miller Class I and II recessions can predictably treated with various periodontal plastic surgical procedures (8,85,86,172). However, the best treatment outcome in terms of CRC and RH reduction is obtained when there is adequate KT apical to the recession defect (5,10,191), therefore only Miller I type of defects were included in this study.

Systematic reviews reported that although 6 month evaluation period for root coverage procedures was considered adequate to provide soft tissue stability and maturation (6,170), it was shown that the length of follow-up was a positive predictive factor in terms of aesthetics, and the follow-up period should not be less than 12 months (219). Therefore, the evaluation period used in this study was 12 months. To our knowledge, no randomized controlled trial has been yet published comparing the TUN with CAF procedure in multiple recession defects using the ADM and reported the results at 12 months. In this aspect, the results will contribute to the literature.

When the TUN is considered, mostly case reports and randomized controlled trials in combination with CTG (67,91–93,95–102) take place in the literature. Other than CTG, TUN is combined with ADM (106,110–112) and collagen matrix (104,105). Previous studies reported results for TUN+CTG, ranging from 74% (99) to 99% (97) for MRC; and from 22% (103) to 85% (104) for CRC (67,91,92,94,95,97,99–103,105,108,214). On the other hand the reports about TUN+ADM were ranging from 61% (106) to 78% (110) for MRC; and from 33% (111) to 50% (110) for CRC with evaluation periods of 4 months (110,111), and 1 year (106). Furthermore, a few case studies reported 100% CRC in the treatment of maxillary recessions with 8 weeks evaluation period (109,112). When TUN is combined with collagen matrix, MRC is reported as 71% (104), and CRC was 42% (104). The results obtained in this study in terms of MRC and CRC are in accordance with the literature (104–106,110,111). In this study, CAF+ADM technique provides better MRC and CRC rather than TUN+ADM. This result can be attributed to couple of factors. Tunnel technique has clinical limitations with regard to the treatment of multiple adjacent defects with different recession heights, due to the limited flap mobility caused by missing vertical incisions; high amount of the graft might be left uncovered. If the graft material is ADM, then it might not work as desirable since it has been reported that when ADM is left uncovered a resorption takes place and ADM works best when vertical incisions are performed (49). On the other hand, when TUN is combined with CTG, even small part of the CTG being left uncovered due to limitations in flap mobility, it survives and successful results are obtained (67,91,93,95,104,107,108,214).

In the present study both TUN+ADM and CAF+ADM sites were prepared to intend the flap could be moved in a coronal direction without tension. Muscle fibers and any remaining collagen bundles on the inner aspect of the flap and alveolar mucosa were separated with extreme care to obtain a passive coronal positioning of the flap. In our study, lower root coverage results in the TUN+ADM group may be due to differences in flap design and vertical incisions. In the CAF+ADM group trapezoidal design with vertical releasing incisions was used, whereas in TUN+ADM group tunnel was prepared without any visible incisions, which may lead to difference in flap tension and coronal repositioning of the flap.

Previous studies indicated that a good result can be obtained with either CAF or TUN and also there are differences in defect coverage between the CAF and TUN, as reported in this study. Papageorgakopoulos et al. (110) treated 24 patients and 24 Miller Class I or II recessions ≥3 mm with TUN+ADM and CAF+ADM. Both groups consisted of 6 maxillary and 6 mandibular teeth. After 4 months, MRC and CRC were 78% and 50%; 95% and 83% in TUN+ADM and CAF+ADM groups, respectively. The difference between the groups found statistically not significant ($p>0.05$) but the authors considered the results as clinically significant. Our results was similar to the report of Papageorgakopoulos et al. (110) but the primary differences between two studies were the defect configuration and evaluation period. In that study 24 patients and 24 single recessions were treated with TUN+ADM and CAF+ADM and followed for 4 months. In the present study, we were treated 20 patients with 58 multiple recessions with TUN+ADM and CAF+ADM approach and followed for 12 months. In the present study, multiple recession defects were treated, that increases the surgical difficulty and the risk of failure when compared with single recessions, that will affect the MRC (8,85,87). Shepherd et al. (111) treated 3 maxillary and 6 mandibular teeth in 9 patients with TUN+ADM. After 4 months, MRC was 70% in TUN+ADM treated sites.

Modarressi & Wang (106) treated 5 patients with 2 to 5 adjacent defects with TUN+ADM. Mean root coverage was 75.46% at 90 days, 58.67% at 180 days, and 60.5% at 1 year. The result of this study in terms of MRC is similar to above-mentioned studies of TUN combined with ADM for multiple recessions.

Previous studies indicate that releasing incisions are an advantage when coronal positioning is needed and modifications to the TUN may increase level of predictability of the technique (109,110,112,220). Thus, the limitation of coronal positioning the gingival margin following a TUN procedure may affect its predictability when ADM is used as a graft. In the previous studies, multiple gingival recessions were successfully treated with CAF procedures with and without vertical releasing incisions (5,10,11,49,50). Andrade et al. (50) evaluated the treatment outcomes of CAF+ADM approach with or without vertical incisions. Mean root coverage and CRC were 74.32% and 40.0% without vertical incisions; 83.28% and 53.36% with vertical incisions at 12 months evaluation, respectively, and the difference was not significant between the groups with regard to root coverage ($p>0.05$). They concluded that both surgical techniques in combination with ADM, resulted significant RH reduction after 12 months, but the group with releasing vertical incisions leads to statistically significant difference in KT increase, after 12 months ($p<0.05$). Felipe et al. (49) compared a CAF with releasing incisions to an envelope flap without releasing incisions when using ADM as a graft material for both procedures. The procedure with releasing incisions achieved 85% MRC whereas the procedure without releasing incisions resulted in 69% MRC. Zucchelli et al. (11) compared the root coverage of CAF with and without vertical releasing incisions and at 12 months, MRC and CRC in CAF group with vertical releasing incisions were 92.64 ± 14.25% and 43.7%, respectively, whereas in CAF group without vertical releasing incisions MRC and CRC were 97.27±8.08% and 75%, respectively. They concluded that envelope type of CAF resulted with statistically greater probability of CRC ($p<0.05$). Tözüm et al. (95) compared the TUN or CAF procedure in combination with CTG. At 6 months after surgery, statistically significant differences were found between the groups, MRC was 96.4% and 75.5% in TUN and CAF groups, respectively ($p<0.05$). Controversy exists in regard to vertical releasing incisions. Two of the studies mentioned above reported better results with vertical releasing incisions when ADM is used. In Tözüm's study the combined graft is CTG. As we mentioned before, even CTG is not covered completely, due to its nature the graft survives. It can be concluded that when the combined graft choice is ADM it might be better to use vertical releasing incisions. Furthermore, the procedures without releasing incisions are more technique sensitive when using ADM as a graft material.

In multiple defects treated with CAF+ADM, MRC was reported in a range from 55% (53) to 99% (45), and CRC in a range from 7.7% (46) to 87.7% (32) (15,35–37,39,43,44,46,48,50–56,58,81,89,213). A previous study (58) from this institution reported 94.84% MRC with CAF+ADM combination and the results achieved in this study for CAF+ADM group in terms of MRC (93.81%) and CRC (85%) were in accordance with the previous results reported in the literature.

Woodyard et al. (213) evaluated the clinical outcomes of CAF+ADM, MRC and CRC were found 99%, and 67% at 6 months evaluation, respectively. They concluded that CAF+ADM combination leads to significant increase in GT when compared with CAF alone and root coverage was significantly improved with the use of ADM. Harris (37) evaluated the long term stability of root coverage results achieved with CAF+ADM, and MRC was found 91.7% at 12 weeks and 87% at 18 months. The author concluded that clinical results obtained with ADM were predictable and stable over time. Santos et al. (44) treated single or multiple gingival recessions by CAF+ADM. Mean root coverage was 74% and CRC was 50%. They concluded that ADM could be used as good alternative to soft tissue grafts in the treatment of gingival recession defects. Cortes et al. (46) reported the clinical outcomes of CAF+ADM and MRC was 76.18% at 6 months; 68.04% at 24 months, respectively. They concluded that ADM grafted sites resulted greater GT and less relapse of the recession. Thombre et al. (56) evaluated CAF+ADM procedure, after 6 months, MRC was 90%. They concluded that CAF+ADM procedure is an effective procedure for the treatment of multiple gingival recessions. Ahmedbeyli et al. (58) treated multiple recessions with CAF+ADM, at 12 months evaluation MRC and CRC were 94.84%, 83.33%, respectively. They recommended CAF+ADM as an efficient approach for the treatment of multiple gingival recessions with thin tissue biotype. Novaes et al. (36) evaluated the clinical outcomes of CAF+ADM, at 6 months evaluation MRC was 60.0%. They concluded that ADM might be a substitute for palatal donor tissue. Harris (42) evaluated the short-term (mean 12.3 to 13.2 weeks) and long-term (mean 48.1 to 49.2 months) root coverage results obtained with CAF+ADM, in the short-term period MRC was 93.4% and in long-term period it was 65.8%. The authors showed that long-term results of CAF+ADM revealed higher MRC in multiple type defects (70.8%) than single type defect (50.0%) ($p<0.05$).

In the present study, the mean baseline RH in TUN+ADM and CAF+ADM groups were 3.23 ± 0.28 mm and 3.30 ± 0.35 mm, respectively. Intra-group comparisons revealed statistically significant differences for RH reduction, at 12 months after surgery ($p<0.05$). Recession height reductions were 2.45 ± 0.20 mm and 3.10 ± 0.57 mm, in the TUN+ADM and CAF+ADM groups, respectively. When the mean baseline RH ≥ 3 mm, RH reductions for TUN+ADM procedure were reported in a range from 1.89 mm (106) to 2.6 mm (111). For the CAF+ADM procedure, RH reduction was reported in a range from 2.1 (36) to 4.57 mm (38) (9,41,46,47,58,149,198,213,221). These findings are in accordance with the previous studies in the literature (41,46,47,58,106,110,111,198,213,222). Inter-group difference for RH reduction was statistically significant in favour of CAF+ADM group ($p<0.05$).

The orientation of ADM graft also considered as a factor, which may influence the outcomes of the root coverage procedures. Henderson et al. (35) stated that the orientation of the graft did not affect the treatment outcome of root coverage procedures. Even though in our study, ADM graft was oriented with the basement membrane side against the bone and root as suggested by the manufacturer.

Root surface treatment and biomodification is another factor considered in the studies by researchers but the results are controversial (161,223,224). Various adjunctive agents have been proposed for the biomodification (161,224–230). Mechanical treatment of root surfaces at surgery is the treatment of choice. Evidence indicates that either hand instruments or powered instruments, including prophylaxis, result in similar outcomes (3,162,192). There is no evidence to support any beneficial effect of chemical root conditioning in addition to mechanical debridement (84,170,231). In the present study, root planing of the exposed roots was performed with hand instruments to remove the smear layer and expose the collagen fibers of the cementum until the root surfaces were hard and smooth.

The importance of GT for the CRC has been determined in the literature (39,165,168,213,232). Baldi et al. (167) indicated that marginal tissue thickness ≥ 0.8 mm can be coronally positioned predictably for CRC, whereas tissue with less thickness will require a graft, and also thicker marginal tissue may also be more resistant to future recession. Allen & Miller (191) also indicated that thick marginal tissue (~1 mm) was needed for successful root coverage with a CAF alone and also thin marginal tissue is generally considered more prone to additional recession than is thick tissue (233). Ahmedbeyli et al. (58), stated that there is a significant positive correlation between GT and defect coverage. When GT ≥1.3 mm, higher percentage of CRC was achieved. These observations suggested that tissue biotype is a significant factor influencing aesthetic treatment outcomes of root coverage procedures.

In the present study, baseline GT values were close to ≥ 0.8 mm threshold level that reported at previous studies, and GT increase was 0.58 ± 0.07 mm, from 0.82 ± 0.06 mm to 1.40 ± 0.07 mm in TUN+ADM group; and 0.62 ± 0.10 mm from 0.76 ± 0.06 mm to 1.38 ± 0.09 mm in CAF+ADM group, without significant difference between the groups (p>0.05). Previous studies reported a mean GT increase range from 0.1 mm (110) to 0.6 mm (111) when TUN+ADM was used (106,110,111), and in a range from 0.32 mm (213) to 1.03 mm (39) when CAF+ADM performed (39,46,48–50,53,58,213,234), which is consistent with the results in the present study. In the previous TUN+ADM studies, the measurement methods showed differences, Papageorgakopoulos et al. (110) and Shepherd et al. (111) measured GT at sulcus base and at the mucogingival junction level, whereas Modaressi & Wang measured GT at 1 mm and at 3 mm apical to the gingival margin. In our study, GT was measured at the midpoint between gingival margin and mucogingival junction. Based on the previous studies, GT increase in the present study indicated that ADM acts as a graft and incorporated with host tissue, thereby increasing host tissue thickness.

In the present study, KT increase was 0.87 ± 0.42 mm, from 2.34 ± 0.66 mm to 3.21 ± 0.57 mm in TUN+ADM group; and 1.25 ± 0.24 mm from 2.47 ± 0.51 mm to 3.72 ± 0.55 mm in CAF+ADM group, with significant difference between the groups in favour of CAF+ADM group ($p<0.05$). Keratinized tissue increase for TUN+ADM and CAF+ADM was reported in a range from -1.11 (106) to 0.6 mm (110) and 0.11 (52) to 2.95 mm (89), respectively (32,34,36,38–40,42,44–46,49,106,110,111,234). The increase of 1.25 mm in KT in the CAF+ADM group is consistent with the previous studies (32,34,36,38–40,42,44–46,49,234). Papageorgakopoulos et al. (110) reported 0.8 mm KT increase by using the TUN+ADM procedure, while Shepherd et al. (111) reported 0.4 mm KT increase. Modarressi & Wang (106) reported 1.11 mm KT decrease at 12 months after TUN+ADM treatment and showed that the use of the TUN+ADM seems to have minimal positive effect on the KT. It is still unknown exactly how an increase in the KT can occur in recessions treated with CAF+ADM combinations. Considering that ADM is a non-vital graft and that only the cells from the periodontal ligament and gingival connective tissue are capable of inducing the development of a keratinized epithelium. Paolantonio et al. (39) suggested that the inductive properties of the ADM depend on the percentage of colonization of the non-vital graft by host cells deriving from tissues capable of inducing keratinization. However, further studies are needed to clarify the dynamics of the cellular healing process. It was also hypothesized that KT increase could be explained as the tendency for the mucogingival junction line to regain its genetically determined original position after repositioning, or the capability of the connective tissue, deriving from the periodontal ligament, to participate in the healing processes taking place at the dento-gingival interface (235).

In the present study, baseline PD in TUN+ADM and CAF+ADM group was 1.15 ± 0.25 mm and 1.10 ± 0.21 mm, respectively. Probing depth increase was 0.06 ± 0.29 mm in TUN+ADM group and 0.35 ± 0.34 mm in CAF+ADM groups, without statistically significant difference between the groups ($p<0.05$). These findings are in accordance with the previous studies in the literature for the treatment of recession defects that reported PD changes ranging from -0.5 mm to 0.5 mm (34–40,42,46–

50,58,89,213,234). The small increase observed in the PD should not be considered to be clinically relevant because all patients had a healthy sulcus after 12 months.

In our study, attachment gains in TUN+ADM and CAF+ADM groups were 2.33 ± 0.42 mm and 2.75 ± 0.59 mm, respectively, without statistically significant difference between the groups ($p>0.05$). These findings are in accordance with the previous studies in the literature, reporting attachment gains for CAF+ADM, from 0.81 (36) mm to 4.53 mm (45) (35–40,42,45–48,58,89,213,234). On the other hand, TUN+ADM studies just stated significant improvements in attachment gain without any mathematical data (106,110,111). Although histologic analysis has not been performed in this study, the gain probably might represent a combination of new connective tissue and an epithelium attachment as demonstrated by other researchers (43,80,83,176,177,183). Cummings et al. (183) reported that attachment to the tooth was similar for ADM and connective tissue grafts and consisted of a long junctional epithelium and connective tissue attachment.

Previous TUN+ADM studies have indicated that maxillary sites respond better than mandibular sites and TUN+ADM technique for mandibular sites is clearly more technique sensitive and less predictable (110,111). Width of keratinized tissue, difficulty of achieving the same degree of flap release and passive coronal positioning might be considered as potential factors in the difference between dental arches. In the present study, TUN+ADM group consisted of 14 maxillary and 17 mandibular teeth, while CAF+ADM group consisted of 14 maxillary and 13 mandibular teeth. In this study, since the teeth are distributed homogenously, a difference in the treatment outcomes between maxillary and mandibular sites was not observed.

In our study aesthetic outcome of the treatments was evaluated with RES system, because just the achievement of CRC cannot be considered as full success without aesthetic appearance (155). Level and tissue contour of the gingival margin, texture of the soft tissue, mucogingival line alignment and color of the gingiva were evaluated by the RES system. In the present study, the mean RES in TUN+ADM and CAF+ADM groups were 7.30 ± 1.25 and 8.90 ± 1.60, respectively, with statistically significant difference between the groups ($p<0.05$). These findings are in accordance with the aesthetic outcomes of previous clinical trials (67,81,155,197,236). Root coverage aesthetic score system considered CRC as the main goal; therefore the level of gingival margin contributes 60% of the total RES value, whereas other variables affect 40%. After 12 months, CAF+ADM combination achieved better clinical outcomes; therefore better RES values were observed. These findings are in accordance with the aesthetic outcomes of previous clinical trials that reported mean RES with a range between 7.30 (236) and 7.43 (197) for multiple recessions treated with CAF, 7.0 (236) for multiple recessions treated with CAF+CTG, 8.10 (81) for single recessions treated with CAF+ADM, and 9.6 (67) for single or multiple recessions treated with TUN+CTG. Pini-Prato et al. (236) used RES system to evaluate the clinical outcomes of different root coverage procedures in patients with single or multiple recessions. Multiple recessions were treated by means of CAF and CAF+CTG. After 12 months, only 21 of 195 (11%) treated recessions obtained the maximum RES score 10, while 68 recessions (35%) showing CRC obtained lower scores. The mean RES for multiple recessions treated with CAF and CAF+CTG was 7.3 and 7.0, respectively. Jhaveri et al. (81) used RES system for the assessment of CAF+ADM seeded with autologous gingival fibroblasts (test group) and CAF+CTG (control groups) applications. After 6 months, the mean RES for the test group was 8.1, and 7.9 for the control group. Overall, 13 cases (7 of the test group and 6 of the control groups) achieved CRC; only seven of these cases achieved RES score 10. Zuhr et al. (67) also used RES system for the evaluation of aesthetic outcomes of the TUN+CTG and CAF+ enamel matrix derivatives procedures in the treatment of single or multiple gingival recessions. After 12 months, the CRC was 78.6% in the TUN group, whereas 21.4% in the CAF group. The mean RES for the TUN and CAF groups was 9.6 and 6.92, respectively.

In our study, all patients were questioned about their satisfaction with regard to the following patient-centered criteria: root coverage; dentinal hypersensitivity; color, shape and contour of gums; pain, discomfort and handling during surgery; post surgical pain, swelling and complications; cost effectiveness in terms of time and money spent for the surgery (47). Satisfaction was assessed using a three-point rating scale: fully satisfied (3 points); satisfied (2 points); and unsatisfied (1 point). Overall patient satisfactions for TUN+ADM and CAF+ADM groups were 17.10 ± 1.66 and 18.50 ± 1.71, respectively, and there was no statistically significant difference between the groups ($p>0.05$). Patient satisfactions were similar for both groups, but in the TUN+ADM group patients were unsatisfied about shape and contour of the gums, whereas in the CAF+ADM group patients were complained about the comfort after the surgical procedure. The reason could be flap design and vertical incisions in CAF+ADM group, and for the TUN+ADM group it could be partial root coverage, and high patient expectations. Also in the study by Papageorgakopoulos et al. (110), patients generally reported no significant postoperative complications and minimal discomfort with TUN approach. Modarressi and Wang (106) assessed pain and esthetics after TUN+ADM procedure. Patient discomfort was recorded 2 weeks postoperatively and was rated from I (mild) to 5 (severe). The mean discomfort score obtained from the 5 patients studied was 1.6. The overall quality assessment was recorded 6 months postoperatively. Even though this study assessed pain and aesthetics with a different method (Visual Analog Scale), the results were similar. An evaluation of postoperative discomfort showed that patients had minimal discomfort and healed uneventfully. Although a significant difference was not observed between the groups for overall satisfaction, with minimal surgical trauma, TUN+ADM seems to be a better approach to reduce discomfort, however CAF+ADM procedure produced better aesthetic results.

Within the limits of this study it may be concluded that both TUN+ADM and CAF+ADM procedures were effective in root coverage of multiple recession defects, however better aesthetic results and clinical improvements were achieved with CAF and ADM combination. The CAF+ADM procedure resulted in better clinical outcomes along with better final aesthetics compared to TUN+ADM. On the other hand, TUN+ADM resulted in less patient discomfort with minimal surgical trauma. Although TUN is an elegant and valuable technique, modifications in the technique may improve its efficacy when it is combined with ADM. Therefore, further studies with different flap designs will provide insight to the clinician.

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7. CURRICULUM VITAE

İlknur Ozenci was born in 1985, in Kutahya. She graduated from Marmara University Faculty of Dentistry in 2009. She started PhD education at Yeditepe University, institute of health sciences, department of Periodontology in 2010.

Her research (Treatment of Multiple Gingival Recessions With Two Different Approaches) was awarded as Senior Robert Frank Award 2013 Clinical Research 1st Prize at International Association for Dental Research (IADR) 46th meeting in Florence, Italy and as 2nd Poster Prize at 44th meeting of Swiss Society of Periodontology, 2014.

She is a member of the Turkish Dental Association, European Federation of Periodontology (EFP), Turkish Society of Periodontology (TPD), and International Academy of Dental Research (IADR). Currently, she continues her PhD doctoral education in Periodontology at Yeditepe University.