Review

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A Prevailing Approach in Periodontal Plastic Surgery: Tunnel Technique

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Objective: To review the current concepts for the treatment of multiple gingival recessions and present tunnel technique in periodontal plastic surgery.

Data & sources: The literature was searched for review and original research articles and case series relating tunnel technique on the treatment of multiple gingival recessions.

Conclusion: Tunnel technique provides unique treatment option especially for the multiple gingival recessions. Despite the few limitations, accumulating data favours tunnel technique resulted in remarkable outcomes along with better final aesthetics.

Keywords: gingival recessions, periodontal plastic surgery, tunnel technique, connective tissue graft.

Anatomy of the gingiva

Clinically, the gingiva may be regarded as a combination of epithelial and connective tissues that, forms a collar of masticatory mucosa around the teeth of the complete deciduous or permanent dentition and is attached to both teeth and the alveolar process. It covers the alveolar crest, the interdental septa, and the coronal portion of the alveolar process to the mucogingival junction. The tissues of the gingiva have classically been subdivided into several topographical portions: free, attached and interdental gingival. Likewise, the term keratinized gingiva is redundant, as the oral surface of the gingiva, by definition, is lined by keratinizing epithelium. In fact, the gingiva is an anatomical and functional unit with variations in shape, contour and clinical topography that result in part from tissue adaptation to the specific location around teeth. Sufficient amount of keratinized gingiva around teeth and resulting immobility of marginal tissues hinder bacterial invasion of gingival sulcus [1]. Presence of enough keratinized gingiva improves soft tissue thickness and decrease risk for mucosal recessions around dental implants [2].

Gingival recession

Gingival recessions (GRs), is defined as migration of gingival margin to apical aspect with exposure of root surface [3], is a problem that affects the majority of adults in populations. GRs have been classified by several authors [4] and the most preferred classification of the GRs in the last decades probably classification by Miller [5]. Lately, GRs has been reevaluated at "Periodontal Manifestations Of Systemic Diseases And Developmental And Acquired Conditions: Consensus report of Workgroup 3 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions" in the section of "Mucogingival Conditions Around Natural Dentition"[3]. Workgroup 3 of the 2017 World Workshop proposed novel classification of Cairo at all. [6] with with reference to the interproximal clinical attachment level loss on the Classification of Periodontal and Peri-Implant Diseases and Conditions [3].

GRs can be determined as single and multiple by the number of affected teeth. GRs have several etiologies that can be grouped in: anatomical factors (e.g., lack of attached gingival, muscular insertions, tooth

misalignment, inadequate thickness of the alveolar bone plate and root prominences; (e.g., periodontitis or viral infections); iatrogenic factors (e.g., improper restorations) and mechanical trauma (e.g., toothbrushing trauma or lip piercing) [4]. In the new classification, periodontal health was defined free from tissue inflammatory status, based on World Health Organisation [7]. Thin phenotype (≤ 1mm) has been demonstrated being a risk factor for GRs [3]. Some studies reported a positive association, some a negative, and some no association between GRs and tissue thickness [3]. Jepsen at al [3] reported that different orthodontic movement might be significant risk factor for the the soft tissue injuries of thin bucco-lingual gingival thickness.

Management of GRs

Until today, clinicians and researchers revealed an increasing curiosity in mucogingival and periodontal plastic surgery to restore soft tissue around teeth and implants. Mucogingival therapy is a general term that depicts periodontal treatment involving procedures for correction of mucosal defects, amount of soft tissue and underlying bone support around teeth and implants [8]. Mucogingival surgery introduced by Friedman in 1957 [8], included surgical approaches to save gingival tissue, eliminate frenal or muscle attachments and boost the depth of the vestibule. Periodontal plastic surgery term initially suggested by Miller in 1993, was defined as "surgical procedures performed to prohibit or correct anatomic, developmental, traumatic or disease-induced defects of the gingiva, alveolar mucosa or bone"[9]. This definition involves manifold soft- and hard-tissue procedures; soft tissue augmentation, root coverage, elimination of mucosal recessions around dental implant, crown lengthening, gingival preservation of ectopic tooth eruption, removal of frenal attachments, socket preservation after tooth extraction and bone augmentation of the edentulous ridge.

GR can be treated with various surgical techniques and root coverage can be obtained. Height of the interdental periodontal tissue, including (interproximal bone level and clinical attachment) is the key factor for evaluation of root coverage [5].

Periodontal health along with sufficient keratinized gingival and gingival thickness, complete root coverage and aesthetic integrity is considered to be the essential aims in the treatment of GR [10]; whereas aesthetic demands, dentine hypersensitivity and obtaining sufficient keratinized tissue support have been the most indications for the treatment of GRs.

Takei et al. [11] classified root coverage procedures in the treatment of GR as follows:

Pedicle Grafts (Pedicle Flaps)
Rotation Flap Procedures
Laterally Sliding Flap [12],
Double Papilla Flap Technique [13],
Oblique Rotated Flap [14].

Advanced Flap Procedures
Coronally Advanced Flap (CAF) [15],
Semilunar Advanced Flap [16].

Free Grafts

Free Gingival Graft (FGG) (Bjorn 1963)
Single stage (FGG) [17],
Double stage (FGG + CAF) [15].

Subepithelial Connective Tissue Graft [18],
Subepithelial Connective Tissue Graft + Rotation Flap [19],
Subepithelial Connective Tissue Graft + Pouch Technique [20],
Tunnel Technique [21].

Root Surface Bio-modification Theraphy
Citric Acid [22],
Tetracycline Hydrochloride [23],
EDTA Fibrin-Fibronectin Complexes [24].

Biomimetic Approach
Enamel Matrix Protein Derivatives (EMD) [25],
Acellular Dermal Matrix Allograft (ADM) [26],
Guided Tissue Regeneration (GTR) [27].

Laterally Sliding Flap. This technique has been initially proposed by Grupe & Warren [12], is advocated when the local anatomic condition disallowed the CAF technique. The laterally sliding flap is commonly used to cover isolated, denuded root surface that has sufficient lateral donor tissue volume and vestibular depth. Various modifications [28] have been proposed to avoid the reported undesirable results on the donor teeth.

Double Papilla Flap Technique. Cohen et al. [13] suggested in 1968, Double Papilla Flap technique for the treatment of localized gingival recessions. This technique mostly preferred for treatment of isolated recessions offers the advantages of dual blood supply and prevent permanent damage interproximal are after surgical exposure. It also offers the advantage of patient morbidity and reduces the risk of facial bone height loss.

Oblique Rotated Flap Technique. This procedure facilitates to manage gingival recession without gingival grafts. Oblique rotation flap operation, which is a modification of the horizontally repositioned flap and other advanced procedures. This technique provides to obtain sufficient keratinized tissue, in addition, eliminates aberrant frenal attachment [14].

Coronally Advanced Flap (CAF). The CAF procedure is very popular and most acceptable approach for root coverage. Coronal shift of marginal tissue complex on the denuded root surface has revealed the name of the technique. CAF technique initially was defined by Norberg in 1926. This technique was first described and published by Bernimoulin [15] in 1975. As a result, the exposed root surface is tried to be covered by repositioning the mucosal flap via the coronal direction. Conditions required to perform the CAF procedure are the presence sufficient height (1 mm for shallow recessions, 2 mm for severe recession ≥5 mm) [9] and thickness of keratinized gingival at apical area [29]. Zucchelli & De Sanctis modified this technique and described novel approach – Modified CAF technique [30].

Semilunar Advanced Flap. Semilunar technique was defined by Tarnow[16]. In this method, semilunar incision has been performed to parallel the root surface minimum 2-3 mm away from the gingival papillae. Followed by, the partial thickness flap shifted coronally to cover the exposed root surface.

Free Gingival Graft. The free gingival grafting (FGG), first described by Bjorn in 1963, is the most effective procedure to increase the width of attached gingival recession area [31]. FGG is mostly used when the main goal of the surgical procedure is to augment attached gingiva height, but undesirable aesthetic results and incomplete root coverage should be taken into account.

Root Biomodification. The main goal of using the root surface biomodifiers is exposing the collagen fibers by the cement to increase the fibrin connection between the graft or flap and the root surface. Mariotti reviewed evaluation effects of biomodifications on the root surface [32]. Consequently, effectiveness of citric acid, tetracycline –HCl, fibronectin and EDTA on the root surface is not evidence for a conclusive evaluation [32].

Biomimetic Approach. Studies indicated that enamel related proteins induced formation of cementum in periodontal regeneration process. Enamel Matrix Derivatives Proteins (EMD) are expressed from Hertwig epithelial cells and induce sementogenesis [25]. Emdogain (Straumann, Basel, Switzerland), is the only FDA approved product, is a purified acidic, containing amelogenins that can be applied to the root surface through the propylene glycol alginate release system.

Acellular Dermal Matrix Allografts. Acellular dermal matrix allograft (ADM) is derived from dermis layer of human skin tissues consisting of cell-free, frozen-dried, collagen and elastin fibrils. ADM is widely accept accepted for root coverage in the treatment of gingival recessions. Using FDA proved ADM allograft AlloDerm provides to increase gingival thickness and root coverage [26].

Guided Tissue Regeneration (GTR). Production of barrier membranes brings about to commence GTR procedure on the treatment of gingival recessions. In the treatment of gingival recessions, both of resorbable and non-resorbable barrier membranes are used. Membranes provide to create a gap space causes tissue regeneration on recession region. For the first time, barrier membranes are used for root coverage by Pini Prato et al. [27] in 1992.

Tunnel Technique

The treatment of multiple GRs, encountered many challenges, such as different anatomical contours, the large surgical area, the diversity of keratinized gingival volume the requirement of large grafts and inadequate thickness of fibro-palatal mucosa. These difficulties cause attempts to improve variety of treatment methods in periodontal plastic surgery. Also, treatment of multiple recessions must consider the total number of surgical procedures, the amount of donor tissue that can be obtained from the palate and patients' esthetic requests.

Raetzke reported the first "Envelope technique" for root covering isolated gingival recession in 1985[20]. Raetzke performed the treatment of single gingival recessions and evaluated 12 gingival recessions area in a total of 10 patients in the case series. Split-thickness flap elevated and a an envelope bed was prepared, CTG, then CTG was fixed with cyanoacrylate without suturing and periodontal dress [20]. After 8 months, average root coverage was 80%. As a result, it has been suggested that the "envelope" technique is the preferable method in the treatment of single gingival recessions.

Later on, Allen [14] created a partial-thickness supraperiostal envelope and modified the envelope technique in the treatment of multiple gingival recessions his case report in 1994 [21]. In this method, sulcular incisions were used to the papillary complex as an internal bevel. Partial-thickness supraperiostal envelope was extended 3-5 mm lateral and apical directions away from recession area. After harvesting palatal graft, CTG was inserted in the supraperiostal envelope and the papillary complex and graft were fixed with vertical matrix sutures. In this method, it has been reported that the papilla elevation causes the movement of flap coronally.

Azzi et al.[33] modified the Allen method and reported coronally advanced modified tunnel technique. In this study, CTG harvested from tuberosity area. Interdental areas in the relevant area with gingival recession temporarily splinted with composite. The graft and gingiva-papillary complex were coronally advanced, fixed with 4.0 silk sutures using a vertical matrix technique. Later on, horizontal matrix sutures were performed [33].

Although Allen's [21] paper is considered the first "tunnel method" in the history of tunnel technique, Zabalegui et al. later coined the first term "tunnel" in periodontal plastic surgery [34]. Zabalegui et al. described papillary partial-thickness elevation made multiple envelope tunnels in the treatment of Miller class I and II gingival recessions [34]. Partial-thickness papillary elevation was performed with sharp dissection extended 3-5 mm to mesial, distal and laterally. CTG inserted tunnel recipient bed with auxiliary sutures and fixed vertical mattress sutures on the both of terminal.

As a result, this method reported representing highly predictable results in the treatment of multiple and single gingival recessions[34].

Zuhr et al. [35] represent to develop a microsurgical approach and new tunnel instrumentation in periodontal plastic surgery. In this case report, authors described creating a tunnel bed through supraperiostal elevation of buccal gingivopapillar complex following sulcular incision. Microsurgery sharp tunnel instruments provide dissection of the entire buccal aspect is performed as a mucosal flap without perforation. CTG harvested form hard palate through "single incision technique" [36]. After immediately CTG inserted in tunnel bed with supportive sutures and microsurgical instruments. The gingivo-papillary complex was shifted to the coronal position and fixed with vertical matrix sutures. As a result, modification of method and microsurgery instruments increased aesthetic outcomes on the tunnel procedures [35].

Zuhr et al. [37] reported novel modification suture technique-double crossed sutures in tunnel technique. This suture technique provides the opportunity to stabilize the gingivo-papillary complex in a coronal position and to improve adaptation flap-graft unity to root surface [37].

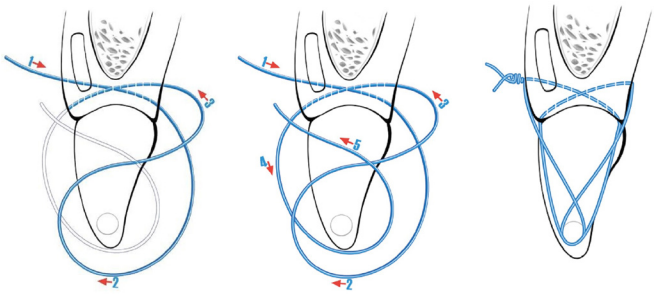

Figure 1. Double-crossed suture technique: penetrate from buccal side (1) to the palatal side and wrapping around the contact point (2), back to the palatal side (3). Again starting from the palatal side to the buccal side (4), wrapping around the contact point and passing underneath the contact point back to buccal side (5).

Aroca et al. [38, 39] proposed the "coronally advanced modified tunnel technique" includes a mucoperiosteal flap elevation that separates papillae from interproximal bone tissue. Aroca et al. reported the treatment Miller class III multiple gingival recessions total of 139 regions of 20 patients in their randomized clinical trials. Twenty healthy subjects with a mean age of 31.7 years, were enrolled for the trial in a university periodontal clinic. Patients with at least three adjacent gingival recessions on both sides of the mouth were treated with a modified tunnel/CTG technique. On the test side, an EMD was used in addition. Clinical parameters were measured at baseline, 28 days, 3, 6 and 12 months after the surgery. Gingival recessions in the test group were treated by CTG + Modified tunnel technique + EMD, only CTG +Tunnel technique results were evaluated in the control group. Average root coverage 83% in the test group and 82% in the control group. Aroca et al. [39] reported that, Tunnel technique was predictable technique in Miller class III treatment.

Aroca et al.[38] reported to involve twenty-two patients with a total of 156 Miller Class I and II gingival recessions in this study. Recessions were randomly treated according to a split-mouth design by means of MCAT(modified coronally advanced tunnel) + CM (collagen matrix) (test) or MCAT + CTG (control). The following measurements were recorded at baseline (i.e. prior to surgery) and at 12 months: Gingival Recession Depth (GRD), Probing Pocket Depth (PD), Clinical Attachment Level (CAL), Keratinized Tissue Width (KTW), Gingival Recession Width (GRW) and Gingival Thickness (GT). GT was measured 3-mm apical to the gingival margin. Patient acceptance was recorded using a Visual Analogue Scale (VAS). The primary outcome variable was Complete Root Coverage (CRC), secondary outcomes were Mean Root Coverage (MRC), change in KTW, GT, patient acceptance and duration of surgery. No statistically significant difference in the rate of CR for both groups (control group 85% of the test group 42%) has been reported. As a result, the present findings indicate that the use of CM may be an alternative to CTG. Using CM to reduce surgical chair time and patient morbidity but the success rate is low in a long time has been reported [38].

Sculean and Allen [40] developed a new technique-Lateral Closed Tunnel (LCT) in the treatment of mandibular localized gingival recession. In this method, a mucoperiosteal pouch were was prepared via microsurgical scalpel with a sulcular incision on the gingival recession canine tooth. The tunnel (pouch) bed was extended beyond the mucogingival line and mesiodistally. Emdogain (Emdogain, Straumann, Basel, Switzerland) was applied after the root surface. CTG was harvested according to the size of the recession site and sutured to the tunnel area using a modified matrix suture method. This study included 24 patients, Miller class I, II, and III gingival recession. After 12 months, CRC rate was 70.83% on 17 gingival recession sites. As a result, the LCT method is a predictable new tunnel modification in the treatment of deep mandibular Miller class I, II and III gingival recessions [40].

Azaripour et al. [41] showed a comparison of the CAF + CTG and modified tunnel + CTG methods in the treatment of Miller class I and II gingival recession. A total of 71 gingiva recession sites were treated in 40 patients. End of 12 months, has been reported that there was no significant difference on the CRC (CAF 97% and Tunnel 98%) at both groups.

Tavelli et al. [42] reviewed the predictability and effectiveness of the tunnel technique in the treatment of multiple and single gingival recessions in their meta-analysis study. As a result, the tunnel technique was high effectiveness pathway on the treatment of single and multiple gingival recessions, has been reported in meta-analysis research [42]. Many modifications of the tunnel technique, such as half-thickness flap elevation, microsurgery approach provide to increase final results and predictability [42].

Pathway of the tunnel surgical procedure:

- The tunnel bed is prepared with a sulcular incision at each area of recession region involved in the procedure. Tissue elevation beyond the mucogingival junction in order to obtain a tension-free tunnel, allowing the insertion of the graft.
- CTG is harvested from the palate, to obtain a graft long enough to achieve root coverage of all involved teeth. Incision can be extended from the canine area to the tuberosity
- CTG inserted into the tunnel bed by applying a auxiliary sutures with both sides.
- CTG is slightly moved into the tunnel bed, sliding under the interdental papillae. Tunnel instruments may help to adapt the graft into the tunnel.
- Graft and gingivopapillary complex was stabilized with "double vertical cross" sutures.

Figure 2 shows a complex clinical case of multiple gingival recessions treated using the connective tissue graft + tunnel technique.

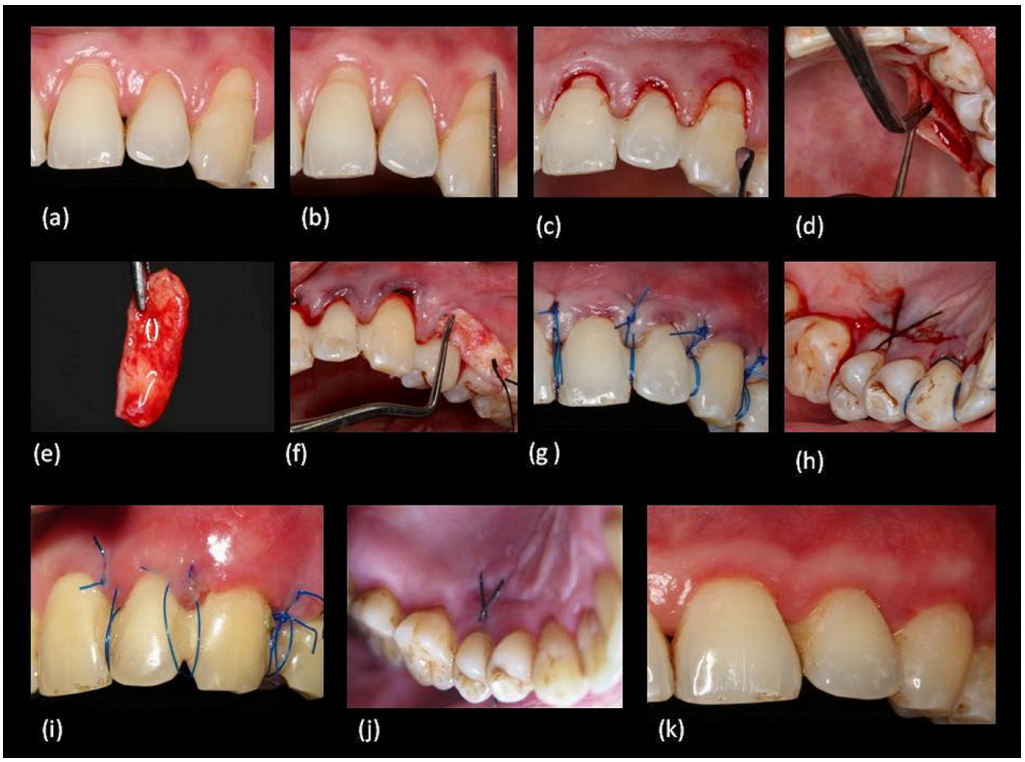

Figure 2. Surgical approaches to multiple gingival recessions with tunnel technique. (a) Baseline image of Miller class I defects on upper right anterior teeth. (b) Measurement of gingival recession depth. (c) Gingivo-papillary elevation via tunnel microsurgery knives. (d) Single incision procedure to CTG harvesting. (e) Harvested CTG. (f) Graft insertion into tunnel bed. (g) Double vertical cross suturing image. (h) Post-surgical primary closure of donor area. (i) One-week post-surgical image recession region. (j) One-week post-surgical image donor area. (k) A 12-month post surgical image.

Graft Selection

Tn the presence of multiple defects, the attempt to reduce the number of intraoral surgical sites, together with the need to satisfy the patient's esthetic demands, must always be taken into consideration. Thus, when multiple recessions affect adjacent teeth they should be treated at the same time and, if possible, the removal of soft tissue from distant areas of the mouth (palate) should be minimized to reduce patient discomfort [4]. Therefore, successful outcomes have been reported simultaneous harvesting and using CTG and de-epithelization FGG on the treatment of gingival recession with tunnel technique [43, 44]. The subepithelial connective tissue graft is a predictable and versatile technique in treatment of gingival recessions. Initially, Edel [45] suggested that, subepithelial connective tissue carries the necessary genetic message for keratinization. Langer and Langer [18] describe using CTG for root covering in 1985. Some surgical techniques have been applied and improved to harvest CTG; "trap to door" [45], "L technique" [46] and "single incision technique" [36].

The advantages CTG harvesting comprises primary closure healing of the donor area, the patient's low post-operative pain and discomfort, sufficient blood supply in the recipient site and aesthetic tissue chromatization. Chambrone et al.[47] revealed that, subepithelial connective tissue grafts provide significant root coverage, clinical attachment and keratinized tissue gain in systematic review. Overall comparisons allow us to consider it as the 'gold standard' procedure for root coverage in periodontal plastic surgery [47-49].

The most important disadvantages of this technique are the need for an additional donor area and the surgical technique requires enough surgical experience. In addition, the healing period has been concluded usually with a long junction epithelium, and a small amount of connective tissue attachment [19]. Pasquinelli [50] reported to incease new attachment, the amount of cement and alveolar bone after treatment of gingival recessions with CTG.

Besides, the traditional methods of using CTG with tunnel technique in the treatment of gingival recessions, many alternative products as de-epithelialized palatal grafts, collagen matrix, acellular dermal allo- and xenografts have been studied [38, 44, 51, 52]. When palatal fibromucosal tissue thickness was insufficient (≤2.5 mm), apico-coronal or mesiodistal sizes grafts were required [32, 39-42, 44, 47, 156], de-epFGG may be an alternative to CTG. Bertl et al. [53] showed that, de-epithelialized palatal grafts contain higher amounts of dense collagen and connective tissue and low amounts of glandular and adipose tissue compared to conventional CTG, as a result of histomorphometric analysis. Therefore, minimum tissue shrinkage and graft resorption have been reported [54]. Azar et al. [55] reported that, de-epFGG could be considered as "predominantly dense CTG", included minimum adipose and epithelial tissue. Evaluation of epithelial tissue remenants remnants on long term clinical outcomes requires further clinical research [55, 56]. Tavelli et al. [57] showed to obtain high mean RC, KT and clinical attachment level (CAL) results with de-epithelialized palatal graft +CAF than CTG. McLeod et al. [44] initially used de-epithelialized palatal graft with tunnel technique on the treatment of mandibular Miller class I and II gingival recessions. Mcleod et al. [44] reported that, this procedure is practical than other CTG harvesting technique, using a de-epFGG result in to increase KT, gingival thickness and average RC 80-100%.

Conclusion

To the important author's research, this review presents unique places of tunnel technique in periodontal-plastic surgery. Tunnel technique is highly effective in treating gingival recession defects. Tunnel technique provides treatment of gingival recessions without vertical incision and scar tissue formation, especially anterior zone. Tunnel technique ensures better blood supply, which improves wound healing, graft fusion, causes successful root coverage and CAL gain. Periodontics should carefully examine every method before cases. Surgical experience, microsurgical approach and technique modification may improve final outcomes.

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