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Mandibular Gingival Recessions: A Challenge of Achieving Complete Root Coverage in Periodontal Plastic Surgery?

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Abstract

Management of gingival recession has been one of the primary interests of periodontal research for many years. Periodontal plastic-aesthetic surgery has advanced due to the understanding of periodontal conditions, anatomical factors and integration of recession classification into pre-operative planning. As a result, complete root coverage is achieved frequently in most cases and has become the criterion for success. However; mandibular gingival recessions still proved to be a challenge for clinicians when widely accepted techniques that showed high predictability of root coverage were applied. To address this clinical condition on the mandible, innovations of accepted surgical procedures have been published. In the present review, we compiled and elucidated the developments made in the treatment protocols for mandibular gingival recessions.

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1. Introduction

Gingival recessions (GR) are defined as ‘the apical shift of gingival margin caused by different conditions and/ or pathologies, associated with clinical attachment loss (Jepsen et al., 2018). This condition, when present, can impair patient aesthetics and comfort (i.e., hypersensitivity) (Nieri et al., 2013; Vignoletti et al., 2020), but may also increase the risk for root caries (Bignozzi et al., 2014; Cortellini & Bissada, 2018).

Factors such as aggressive toothbrushing (Baker & Spedding, 2002; Gorman, 1967; Kassab & Cohen, 2003), traumatic occlusion (Akerly, 1977), foreign body reactions (i.e., piercing, removable prosthetics) (Er et al., 2011), anatomical variances of gingiva and bone (e.g, lack of keratinized tissue (KT), thin soft/hard tissue phenotype, alveolar dehiscence) (Gorman, 1967; Kassab & Cohen, 2003; Wennström, 1996), aberrant frenulum (Kassab & Cohen, 2003; Wennström, 1996), and iatrogenic factors contribute to GR. While maintaining good periodontal health may negate the need for a minimum amount of KT (Jepsen et al., 2018), adequate keratinized gingiva (≥ 2 mm KT, ≥ 1 mm attached gingiva) promotes gingival health and insufficient KT with poor plaque control may lead to GR and inflammation (Kim & Neiva, 2015; Patel et al., 2011). In addition, untreated buccal gingival recessions often show an increase in recession depth (RD) (Chambrone & Tatakis, 2016).

The mandibula exhibits a higher prevalence of GR than the maxilla, with mandibular incisors most frequently affected, followed by maxillary molars and mandibular premolars (Mythri et al., 2015). Deep GR on mandibular incisors is commonly observed in

patients with a history of orthodontic treatment, likely due to the direction of tooth movement and bucco-lingual gingival thickness (Renkema et al., 2013; Kim & Neiva, 2015).

The treatment of these conditions is well-documented but varies in predictability based on recession type and tooth (Cairo et al., 2011; Chambrone & Tatakis, 2015; Zucchelli et al., 2018) and success in mandibular sites is less predictable than in maxillary sites (Chambrone & Tatakis, 2015; Zucchelli et al., 2018), largely due to anatomical factors like the high insertion of the labial frenulum, thin marginal tissue, and limited vestibular depth, all of which make surgery on the mandibular incisors particularly challenging (Zucchelli et al., 2014). Additionally, caution is required around the mental nerve to prevent injury (Mazzotti et al., 2023).

Considering the data from the literature, the treatment of mandibular GR requires unique surgical viewpoints and techniques to consider. Furthermore, since mandibular GR has posed significant challenges, researchers have explored various methods to achieve root coverage with minimal post-operative morbidity or have modified existing techniques to improve outcomes. Therefore, this review aims to present and compile periodontal plastic surgical techniques used for the treatment of mandibular GR, with a focus on root coverage outcomes (RC).

2. Free Gingival Graft (FGG)

The use of pedicle grafts, particularly free gingival graft (FGG) (Bjorn, 1963; Edel, 1974; Haggerty, 1966; Nabers, 1966; Sullivan & Atkins, 1968), was

proposed in order to increase the width of KT and soft tissue volume as the understanding of genetic determinants of gingival tissues advanced in subsequent years (Karring et al., 1975; Karring et al., 1975; Karring et al., 1971). In the 1970s, the concept of RC began to replace the focus on increasing KT in mucogingival surgery (Figure 1). FGG became the first step in a two-stage surgery to create an attached gingiva before coronally positioning the flap for GR reduction (Bernimoulin et al., 1975; Harvey, 1970). Miller's GR Classification (Miller Jr, 1985) later highlighted both the limitations and effectiveness of FGG as a single-step procedure for RC.

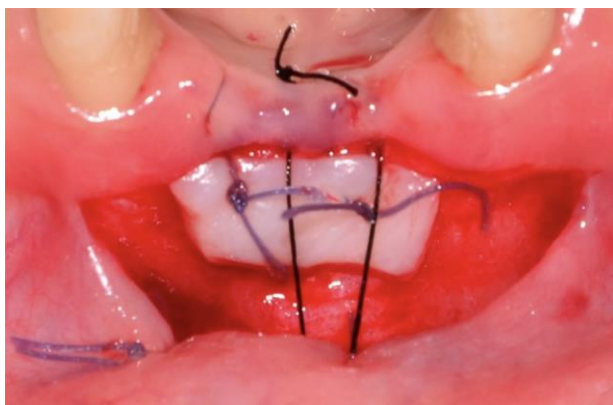


Figure 1. Free Gingival Graft for Keratinized Tissue Augmentation

2.1. FGG for RC Outcomes

Throughout the 1970s and 1980s, FGG remained the gold standard in mucogingival surgery (Prato & Gianfilippo, 2023). However; the majority of previous studies have not included the distinction between maxillary recessions from mandibular recessions (Jahnke et al., 1993; Liu & Solt, 1980; Matter, 1979; Miller Jr, 1985; Miller Jr, 1987; Paolantonio et al., 1997). The reasoning could be attributed to the high predictability of surgery and favourable prognosis where 100% RC is anticipated in Miller I and II cases

regardless of the location (Camargo et al., 2001; Miller Jr, 1985) (Figure 2).



Figure 2. Free Gingival Graft for Root Coverage

A systematic review on mandibular Miller I/II/III and RT 1&2 recessions reported that FGG achieved a mean MRC of 8.5% and CRC of 14% (Agusto et al., 2022), with lower predictability likely due to anatomical limitations and the inclusion of varied recession types. Limited data exists on Miller IV recessions treated with FGG (Miller & Binkley, 1986), as reviews have largely focused on connective tissue grafts (CTG) for Miller III/IV cases (Bertl, Spineli, Mohandis, & Stavropoulos, 2021; Aitziber Fernández-Jiménez et al., 2021). Despite frequent aesthetic limitations (Camargo et al., 2001; McGuire, 1990; Miller Jr, 1987), innovations like modified FGG (modFGG) which translocates pedicle connective tissue beneath FGG have shown promising results for RC outcomes (Carcuac et al., 2023). Thus, according to the evidence presented in case series and randomized controlled clinical trials, FGG is still relevant for RC in anterior mandibular Miller I/II and RT I cases (Table 1).

3. Connective Tissue Graft (CTG)

The 1980s marked a revolutionary shift in periodontal plastic and aesthetic surgery. Langer and Langer pioneered the use of CTG underneath a split-thickness pedicle flap, partially covering the graft to improve RC and aesthetics (Langer & Langer, 1985). In the same year, Raetzke developed an 'envelope' technique, using intrasulcular partial-thickness

incisions to create a foundation for tunnelling methods, aiming for minimal morbidity and enhanced aesthetics (Raetzke, 1985). Nelson later refined CTG with bilaminar grafting, using sliding and double papilla flaps to improve vascularization and prevent necrosis, enhancing surgical outcomes (Nelson, 1987). In 1994; Bruno further modified Langer & Langer technique (Langer & Langer, 1985) by using

only horizontal incisions at the CEJ and internal dissection of the flap; omitting vertical incisions entirely; to achieve RC and aesthetics (Bruno, 1994). Following this paradigm shift in literature; the still widely applied version of “bilaminar technique” has been presented in literature (Zucchelli et al., 2003).

Table 1. Root Coverage Outcomes from Studies Involving Mandibular Gingival Recession- Free Gingival Graft

| Study | Year | Diagnosis | Intervention | MRC | CRC | Follow-Up |
|--|------|---------------|--|----------------|-----------|-----------|
| Kuru & Yildirim (Kuru & Yildirim, 2013) | 2013 | Miller I & II | <ul style="list-style-type: none"> • FGG • Gingival Unit + FGG | 67% 91.6% | 0% 50% | 8 months |
| Goyal (Goyal, Gupta, Gupta, & Chawla, 2019) | 2019 | Miller I & II | <ul style="list-style-type: none"> • FGG | 82.22% | NR | 9 months |
| Yilmaz (Yilmaz, Comerdov, Kutuk, Nart, & Keceli, 2022) | 2022 | RT 1 & RT 2 | <ul style="list-style-type: none"> • FGG | 63.5% | 20% | 12 months |
| Parlak (Parlak, Yilmaz, Durmaz, Toz, & Keceli, 2023) | 2023 | RT 1 & RT 2 | <ul style="list-style-type: none"> • FGG | 63.95% | 26.3% | 6 months |
| Carcuac (Carcuac, Trullenque-Eriksson, & Derks, 2023) | 2023 | RT 1 | <ul style="list-style-type: none"> • FGG • modFGG | 60.7% 91.8% | 0% 88% | 12 months |

3.1. Coronally Advanced Flap (CAF)

Allen and Miller (1989) introduced a simplified approach to correct GR by coronally advancing the flap with two vertical incisions on the mesial and distal papilla, without any soft tissue graft (Allen & Miller, 1989). This technique later became foundational, modified for routine periodontal aesthetic surgery to achieve reliable RC (Zucchelli et al, 2003; De Sanctis & Zucchelli, 2007). Zucchelli et al. (2000) further refined this by eliminating vertical incisions to treat multiple GR sites more effectively (Zucchelli & De Sanctis, 2000).

3.2. CTG + CAF

In 1992; complete coverage of CTG with CAF as a predictable method for RC has been proposed by Harris (Harris, 1992). Building on Edel’s graft acquisition (1974) (Figure 3) and techniques by Langer & Langer (1985) and Nelson (1987), Harris declared that ‘*predictable root coverage is a reality*’ and an ‘*obtainable goal*’ (Edel, 1974; Langer & Langer, 1985; Nelson, 1987; Harris, 1992). Later studies confirmed this approach’s effectiveness (Jahnke et al., 1993; Wennström, 1996) and further refinements; including split-full-split thickness flaps and CEJ-based incisions; improved predictability and

aesthetics (de Sanctis & Zucchelli, 2007; Zucchelli et al., 2003).



Figure 3. Connective Tissue Graft Acquisition

CTG has since become central to achieving CRC and aesthetic outcomes over CAF alone (Cortellini et al., 2009; Zucchelli et al., 2003). Zuhr et al. (2014) theorized *‘that the presence of CTG could stabilize the CAF and eventually serve as an ‘anchor’ for the covering flap during initial wound healing’* (Zuhr et al., 2014). CTG + CAF is now considered the gold-standard for reliable CRC and MRC outcomes (Chambrone et al., 2019; Chambrone & Tatakis, 2015) (Figure 4).



Figure 4. Connective Tissue Graft + Coronally Advanced Flap

3.3. CAF and CTG + CAF on RC Outcomes

As the CAF and CTG + CAF became standard in periodontal plastic-aesthetic surgery (Chambrone et al., 2019), numerous studies documented their

predictability and success in RC outcomes and the aim of the research has focused on achieving CRC (Cairo et al., 2010; Cairo et al., 2009). Recent studies further support CRC as the most anticipated outcome by reporting >80% MRC and at least 66% of patients obtaining complete recession reduction (Bertl et al., 2021).

Nevertheless; the treatment of GR involving mandibular incisors has been a challenge for it has been shown to have varying RC outcomes ranging from 53.8% to 75% (Zucchelli et al., 2018) and the literature has presented modifications of existing procedures in order to address this (Carcuac et al., 2023; Fernández-Jiménez et al., 2024; Sculean & Allen, 2018; Stefanini et al., 2021; Zucchelli et al., 2014).

3.4. V-CAF (Vertically CAF)

Zucchelli et al. presented the removal of labial submucosal tissue (LST) added to the trapezoidal-type of CAF (de Sanctis & Zucchelli, 2007) which resulted in the creation of a vertical dimension for CAF (Zucchelli et al., 2014). By eliminating LST, they intended to prolong the muscle reattachment that would cause early shrinkage of CAF and achieve a tension-free closure (Zucchelli et al., 2014). Recent clinical data have promising results on V-CAF for increasing vestibular depth, tissue thickness and aesthetics which indicates that it is a highly preferable alternative to FGG. However, there is no consensus yet for which technique is more predictable in obtaining RC and CRC at mandibular anterior teeth (Parlak et al., 2023; Stefanini et al., 2021; Zucchelli et al., 2014). Table 2 summarizes the results of clinical trials, case series, and randomized controlled clinical

studies that assessed the effectiveness of CAF+ CTG in treating RC for mandibular teeth.

Table 2. Root Coverage Outcomes from Studies Involving Mandibular Gingival Recession- Coronally Advanced Flap Techniques+ Connective Tissue Graft

| Study | Year | Diagnosis | Intervention | MRC | CRC | Follow-up |
|--------------------------------------|------|------------------------------|----------------------|-----------------|------------|-------------|
| Harris (Harris et al., 2005) | 2005 | Miller I & II | CAF+CTG | 80.2% | NR | 3 months |
| De Sanctis (de Sanctis et al., 2011) | 2011 | Miller I & II (Posterior) | CAF+CTG | 91.2% | %50 | 12 months |
| Nart (Nart et al., 2012) | 2012 | Miller II & III | CAF+CTG | 90.22% | 57.14% | 11.7 months |
| Zucchelli (Zucchelli et al., 2014) | 2014 | Miller I & II (> 3 mm depth) | CAF+CTG V-CAF+CTG | NR | 48% 88% | 12 months |
| Mercado (Mercado et al., 2020) | 2020 | Miller III & IV | CAF+CTG | 57.2% | 0% | 36 months |
| Stefanini (Stefanini et al., 2021) | 2021 | RT 1 | CAF+CTG+EMD V-CAF | 68.36% 98.3% | 10% 90% | 12 months |
| Parlak (Parlak et al., 2023) | 2023 | RT 1 & RT 2 | V-CAF | 70.34% | 47.4% | 12 months |

4. Tunnel Technique (TUN)

Raetzke’s ‘envelope’ technique focused on treating isolated recession defects with minimal post-operative morbidity (Raetzke, 1985). However, in 1994, Allen improved upon the ‘envelope technique’ with a partial thickness internal dissection in order to address multiple adjacent gingival recessions while achieving minimal surgical trauma, incorporating vascular supply of CTG from intact lateral and papillary gingiva and improving aesthetics by maintaining papillary integrity (Allen, 1994). Over the following years, many modifications have been made to the TUN including different suturing techniques, flap designs and preservation of intermediate papillae (Tözüm & Dini, 2003; Zabalegui et al., 1999). Coronally advancement of TUN over CTG came into consideration by Azzi et al. (Azzi & Etienne, 1998; Azzi et al., 2002) and it has been applied since with different methods (Mahn, 2001; Zadeh, 2011) and microsurgical intentions (Zuhr et al., 2007) to achieve

more predictable results with improved aesthetics (Aroca et al., 2010; Blanes & Allen, 1999; Tavelli et al., 2018; Zuhr et al., 2007) (Figure 5). Although the literature has established that TUN is immensely effective in treating GR (Mayta-Tovalino et al., 2023), Tavelli et al. (2018) reported that CAF has been shown to be more predictable compared to TUN in achieving CRC (Tavelli et al., 2018). Contrarily, recent studies have stated that both techniques are significantly similar in achieving RC and CRC (Chang et al., 2024; González-Febles et al., 2023; Mayta-Tovalino et al., 2023) and their existence represents versatility in periodontal plastic aesthetic surgery (Chang et al., 2024).



Figure 5. Tunnel Technique + Coronally Advancement

4.1. Laterally Closed Tunnel (LCT)

Especially in the mandibular anterior area, the risk of flap perforation and flap necrosis is stated to be an

issue to overcome and as an alternative to conventional methods; a ‘*Laterally Closed Tunnel*’ was developed as a modification of TUN by means of suturing tunnel margins (Sculean & Allen, 2018). Following this idea, further clinical trials were conducted focusing on LCT with promising results (Lavu et al., 2022; Quispe-López et al., 2022). In Table 3, the RC outcomes in case series, clinical trials, and randomized controlled clinical trials involving the use of the tunnel technique and its modifications in the treatment of mandibular GR were assessed.

Table 3. Root Coverage Outcomes from Studies Involving Mandibular Gingival Recession- Tunnel Techniques + Connective Tissue Graft

| Study | Year | Diagnosis | Intervention | MRC | CRC | Follow-Up |
|---|------|------------------------------------|--------------------------|--------|--------|-------------|
| Harris (Harris et al., 2005) | 2005 | Miller I & II | TUN-LAT + CTG | 90.25% | NR | 3 months |
| Sculean (Sculean et al., 2014) | 2014 | Miller I & II | modTUN + CTG | 96.25% | 75% | 12 months |
| Thalmair (Thalmair et al., 2016) | 2016 | Miller I & II | modTUN + CTG | 93.87% | 74.6% | 6 months |
| Sculean and Allen (Sculean & Allen, 2018) | 2018 | Miller I & II & III (≥ 4 mm depth) | LCT + CTG | 96.11% | 70.83% | 12 months |
| Guldener (Guldener et al., 2020) | 2020 | RT 1 (≥ 3 mm depth) | LCT or modTUN + CTG + HA | 96.09% | 50% | 6 months |
| Skierska (Skierska et al., 2022) | 2022 | RT 1 & RT 2 | modTUN + CTG | 93.6% | 87.29% | 24 months |
| Quispe-Lopez (Quispe-López et al., 2022) | 2022 | Miller II & III | LCT + CTG | 96.4% | 85.7% | 16.7 months |
| Yilmaz (Yilmaz et al., 2022) | 2022 | RT 1 & RT 2 | modTUN+ CTG | 85.82% | 35% | 12 months |

5. The Importance of Classification of Gingival Recessions, Tooth Location, and Anatomical Considerations on RC Outcomes

The development of GR research led to the isolation of Miller III cases before there was a full understanding of the predictability of RC in relation to tooth position and location. Researchers have since reported favourable outcomes for MRC, with CRC

being a possibility in some cases (Aroca et al., 2010; Esteibar et al., 2011). Thus, further investigation has been made to present the efficacy of GR treatments on Miller III/RT 2 cases for CRC outcomes. Jimenez et al. (2021) have stated that modern literature has presented a CRC rate of 51.11% at 6-month follow-up which later decreased to 32.87% at 12 months and 19.65% at follow-ups greater than 12 months, concluding that achieving CRC on Miller III/RT 2 class recessions is still not predictable (A. Fernández-

Jiménez et al., 2021). For Miller IV cases, it has been stated that improvement of clinical parameters can be expected but the amount of RC cannot be anticipated (Chambrone & Tatakis, 2015) and literature has limited data on long-term RC stability for Miller III and Miller IV GRs (Bertl et al., 2021).

Considering the evidence-based information in the literature, periodontal plastic and aesthetic surgery research has an abundance of data involving maxillary GRs but not as much for exploring the treatment of mandibular GRs (Chambrone & Tatakis, 2015; Tonetti & Jepsen, 2014; Zucchelli et al., 2018). Previous research indicated that treating maxillary GR has resulted in greater recession depth reduction (Chambrone & Chambrone, 2006). As anatomical differences between the maxilla and mandible became evident—such as narrow papilla dimensions in the mandible, the presence of lip muscles, and reduced vestibular depth (de Sanctis & Zucchelli, 2007)—the challenges for clinicians became clearer. This understanding would later drive the literature towards developing and refining existing techniques to improve the predictability of RC in the mandibular jaw (Fernández-Jiménez et al., 2024; Sculean et al., 2016; Stimmelmayer et al., 2011; Zucchelli et al., 2014). Interestingly, recent studies have not revealed any significant difference between mandibular and maxillary GRs treated with CAF (Zucchelli et al., 2018) or Tunnel (Skierska et al., 2022).

Furthermore, Zucchelli et al. (2018) reported higher MRC and CRC in anterior teeth, while postulating that the amount of KT, gingival thickness and initial clinical attachment level (CAL) could be a

determining factor for anticipating RC (Zucchelli et al., 2018).

6. Conclusion

Obtaining CRC and MRC have varying results despite the technique utilized for the treatment of mandibular GRs. Furthermore, the literature has not reached a consensus on the ideal choice of treatment and more RCTs are still needed. Research has shown that the classification of GRs is a reliable indicator of anticipating RC, even though great care should be given to anatomical circumstances for each individual recession and the ideal technique could be decided based on the amount of KT, gingival thickness and initial CAL as mandibular incisors are more frequently affected by GR. To overcome the challenge of mandibular recessions, clinicians should be aware of recession depth, cervically inserted frenulum, orthodontic treatment involvement and habit-induced oral trauma.

Ethical Statement

There is no need to obtain ethics committee permission for this study due to being a review. However, the study was conducted in accordance with ethical principles.

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Presentation Information

This study has not been presented at any conference or journal.

Conflicts of Interest

The authors declare no conflicts of interest regarding this study. Any institution or organization providing funding for this research did not have any role in the design, data collection, analysis, interpretation, or publication to influence or distort the findings.

Author Contributions

The contributions of the authors are as follows: Ahmet Çağlar Kalkan participated in data collection, analysis and prepared the draft of the paper; Burcu Özdemir conducted multiple revisions of the manuscript; Sila Çağrı İŞLER conducted the final revision of the manuscript.

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