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Flap approaches in plastic periodontal and implant surgery: critical elements in design and execution

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Abstract

Aim: To identify critical elements in design and execution of coronally advanced flap, lateral positioned flap and their variations for the treatment of facial gingival recessions or peri-implant soft tissue dehiscences.

Materials and Methods: Clinical studies were identified with both electronic and hand searches, and examined for the following aspects: flap design and incision techniques, flap elevation, root conditioning, flap mobility, flap stability and suturing. Moreover, prognostic factors for complete recession coverage were identified.

Results: Some critical elements are evident in flap design and execution: the dimension and the thickness of tissue positioned over the denuded roots; the use on root surface of enamel matrix derivate; the stability and suturing of the flap in a position coronal to the cemento-enamel junction. The pre-determination of the clinical cemento-enamel junction, smoking status, operator surgical skills and the compliance to a supportive care programme have a role in obtaining and maintaining a complete root coverage.

Conclusions: Different flap approaches are available when performing periodontal plastic surgery, resulting in a great variability in clinical outcomes. The possibility of using pedicle flaps alone to achieve complete soft tissue coverage of facial implant dehiscence has not yet been investigated.

Key words: complete root coverage; coronally advanced flap; flap design; gingival recession; lateral positioned flap; peri-implant plastic surgery; periodontal plastic surgery; prognostic factors; semilunar flap; soft tissue dehiscence

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Periodontal plastic surgery is the definition adopted by the American Academy of Periodontology (AAP) proposed by Miller in 1988 (Miller 1988) to substitute mucogingival surgery; these surgical procedures are performed to correct or eliminate anatomic, developmental or traumatic deformities in morphology, position and/or amount of gingiva (AAP 1996). Conversely, the same definition can now be applied to peri-implant tissues, namely peri-implant mucosa.

In the 1960s and 1970s the aim of mucogingival surgery was essentially to treat so-called mucogingival defects, in particular a dimensional reduction both in thickness and height of keratinized tissue (KT). The rationale for this type of surgery stemmed from the perception that the presence or absence of KT influenced periodontal health (Friedman 1957). At that time, Lang & Löe (1972) demonstrated a relationship between the inflammatory state of marginal tissue and the amount of KT, asserting the need for a critical amount of KT to maintain a good state of health. Following this evidence, surgery was performed to augment the amount of

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KT in all cases where the KT was considered insufficient. At that time, the most widely used mucogingival technique was the free gingival graft (FGG) (Bjorn 1968, Nabers 1966, Pennel et al. 1969, Sullivan & Atkins 1968, Edel 1974, Miller 1982). This technique essentially consisted in withdrawing the tissue using a split-thickness approach from the palatal fibro mucosa or from an edentulous ridge.

An in-depth investigation of the necessity for and the effectiveness of the autogenous FGG in maintaining a periodontal attachment to the teeth was later carried out. It could be stated that the critical aspect in maintaining the attachment level is plaque control which minimizes inflammation, despite the width of KT (Miyasato et al. 1977, Dorfman et al. 1980, Wennström et al. 1981, 1982, Wennström & Lindhe 1983a,b). Nevertheless, FGG and pedicle flaps were frequently employed to cover denuded root surfaces.

A recent consensus assessing the quality of evidence-based procedures in periodontal plastic surgery (Chambrone et al. 2010a) has suggested limiting the use of the definition "periodontal plastic surgery" to indicate procedures connected with the treatment of gingival recessions, "since they are at a higher risk of buccal tactile and thermal hypersensitivity, root abrasion and deterioration of smile aesthetics."

The objective of root-coverage procedures consists in the complete resolution of the recession defect, with minimal probing depths after treatment, along with an aesthetic outcome which results in a complete blending of tissue colour and texture of the treated area with the adjacent soft tissues (De Sanctis & Zucchelli 2007).

As the use of a FGG to cover denuded roots did not give satisfactory results and were at best unpredictable (Miller 1982), the possibility of treating gingival recessions was limited to pedicle flaps: essentially the laterally positioned flap (LPF), described by Grupe & Warren (1956) and the coronally advanced flap (CAF), introduced by Norberg (1926), later modified by Bernimoulin et al. (1975) and Allen & Miller (1989).

Over the last 20 years numerous new surgical techniques have been proposed and tested; essentially all of them are modifications of these two pedicle flap procedures.

The intention of this review is to provide a critical analysis aimed at identifying critical elements in design and execution, analysing clinical studies performed either with a CAF or LPF and their variations.

Materials and Methods

Research strategy

The National Library of Medicine in Washington DC (MEDLINE-PubMed) was explored up to May 2013. The investigation was complemented by manual research of the reference list of every selected full-text article. In addition, full-text reviews published between 1995 and 2013 were obtained and additional manual research was carried out looking for relevant studies by screening these reviews.

Search terms

The following search terms were selected: ((("gingival recession"[MeSH Terms] OR ("gingival"[All Fields] AND "recession"[All Fields]) OR "gingival recession"[All Fields]) AND ("surgery"[Subheading] OR "surgery"[All Fields] OR "surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR "surgery"[All Fields] OR "general surgery"[MeSH Terms] OR ("general"[All Fields] AND "surgery"[All Fields]) OR "general surgery"[All Fields])) AND (("plant roots"[MeSH Terms] OR ("plant"[All Fields] AND "roots"[All Fields]) OR "plant roots"[All Fields] OR "root"[All Fields]) AND ("AHIP Cover"[Journal] OR "coverage"[All Fields]))) OR (mucogingival[All Fields] AND ("surgery"[Subheading] OR "surgery"[All Fields] OR "surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR "surgery"[All Fields] OR "general surgery"[MeSH Terms] OR ("general"[All Fields] AND "surgery"[All Fields]) OR "general surgery"[All Fields])).

Inclusion/exclusion criteria

The inclusion criteria consisted of the following:

- Publications in English.
- Clinical studies describing root/implant dehiscence coverage surgical techniques by means of flap approaches.
- Case reports, case series, retrospective studies, prospective studies, controlled and randomized clinical trials (RCT), systematic review.

The exclusion criteria consisted of the following:

- Pre-clinical studies.
- Clinical studies describing root/implant dehiscence coverage surgical techniques by means of graft adjunction.
- Clinical studies in which the surgical technique had been described in previous reports.

Screening process

A three-stage screening process was performed independently by two reviewers (M.d.S., M.C.). Initially, all the titles were screened to eliminate irrelevant publications. During the second stage, all the selected publications were analysed as abstracts and consequently the full texts of articles fulfilling the inclusion criteria were obtained. In the third stage, through the analysis of all of the selected full texts, the included articles were chosen. After this search, relevant reviews and all reference lists of selected studies and reviews were screened for additional papers that might have met the eligibility criteria. Any disagreements between the two reviewers were resolved following additional discussion.

Study analysis

To examine the development of critical elements in designing and executing a surgical procedure, studies were examined for the following aspects:

- flap design and incision techniques
- flap elevation
- root conditioning
- flap mobility
- flap stability and suturing
- prognostic factors for complete recession coverage (CRC).

Results

Periodontal plastic surgery

The choice of a surgical technique in periodontal plastic surgery depends on several factors that can be categorized essentially as belonging to three groups: the local anatomical characteristics of the site to be treated, the patient's requests and the surgeon's preferences.

The local characteristics to be evaluated are essentially: the number of recession defects to be treated, the size of the recession defect, the height and width of the inter-dental soft tissue, the dimension of papillae near the recession, the height, thickness and colour of the KT apical and lateral to the root exposure, the presence of root caries or cervical abrasions, the depth of the vestibulum and the presence of marginal frenuli or muscle insertions.

Patients may influence the surgical technique selection when concerned about the aesthetic appearance of their smile rather than their tooth hypersensitivity due to root exposure. In such patients, when the aesthetic appearance is their main concern, pedicle flaps are recommended rather than graft techniques as the soft tissue used to cover the root exposure is similar to that originally present at the buccal aspect of the tooth with the recession defect and thus the aesthetic result is more satisfactory (Zucchelli & de Sanctis 2000).

Although the surgeon preferences may not be a major factor influencing the choice of the technique, it would be reasonable to assume that the level of expertise and experience would influence the decision.

Flap designs and incision techniques

Single recession

The presence of a significant amount of KT in the prospective donor site is the prerequisite for the success of both the LPF and the CAF in the treatment of isolated recession-type defects (Zucchelli et al. 2004).

Several systematic reviews (Roccuzzo et al. 2002, Cairo et al. 2008, Chambrone et al. 2010b, 2012) have demonstrated that, when CRC and an increase in KT are the surgical requirements, the addition of a connective tissue graft (CTG) to a CAF offers a more predictable outcome (OR: 2.49 in favour of CAF + CTG for CRC) compared to other surgical techniques. Nevertheless, the pedicle flaps alone may give satisfactory results as they present the advantages of using a single surgical area, thus reducing the morbidity of the patient, producing a better and more natural aesthetic outcome (Wennström & Zucchelli 1996).

The more widely used technique is the CAF, originally described by Allen & Miller (1989). The surgical approach consists in making two vertical releasing incisions lateral to the exposed root, beginning at a point apical to the papilla tip and that extends well into the alveolar mucosa connected with a sulcular incision. In addition, a gingivoplasty of each papilla adjacent to the recession is performed, without reducing the height of the papilla to create the recipient bed for the advanced flap.

This technique has been modified over time. Pini Prato et al. (1992) varied the design of the flap by introducing a horizontal incision in the buccal aspect of the involved tooth that was continued mesially and distally to dissect the adjacent papillae without touching the gingival margin of the adjacent teeth. Two oblique releasing incisions were then carried out from the mesial and distal extremities of the horizontal incision beyond the mucogingival junction. The intent of this modification was to increase the dimension of the flap thus increasing the chances of coronally stabilizing it.

The design of the flap was recently modified by De Sanctis & Zucchelli (2007). The main modifications consist in two 3 mm-long horizontal bevelled incisions mesial and distal to the recession defect. The incisions are located at a distance equal to the depth of the recession from the tip of the anatomical papillae plus 1 mm to allow for the precise advancement of the flap beyond the cement enamel junction (CEJ). Moreover, the two horizontal incisions are not continued with an intra-sulcular incision; on the contrary, the sulcular area is left untouched and becomes the area where the periosteum elevator is inserted when raising the flap. Finally, two bevelled oblique, slightly divergent, incisions are made starting at the end of the two horizontal incisions extending to the alveolar mucosa, in such a way that the bone and the periosteal tissues are not included in the superficial cut and are therefore not involved in the healing process, in the attempt of avoiding anti-aesthetic scars; the facial soft tissue of the anatomical inter-dental papillae, coronal to the horizontal incisions, is de-epithelized to create an area of connective tissue bed where the surgical papillae of the CAF will be sutured. This different design creates very wide surgical papillae thus providing a larger area to anchor the flap to the underlying vascular bed and improves the vascular area for nutritional exchange between the flap and the recipient bed. Such differences could in part explain the higher percentage of root coverage (RC) and CRC (Table 1) obtained in different studies (Cairo et al. 2008, Chambrone et al. 2010b, 2012).

When a very shallow vestibulum is present, the semilunar flap (SF) or a double lateral bridging flap (DLBF) could be considered according to some authors (Sumner 1969, Marggraf 1985, Tarnow 1986, Romanos et al. 1993, Sorrentino & Tarnow 2009).

The SF (Sumner 1969, Tarnow 1986, Sorrentino & Tarnow 2009) essentially consists in a semilunar incision, carried out following the outline of the gingival margin. This incision curves apically to an extent guaranteeing that the apical part of the flap rests on the bone following the coronal advancement to cover the root; the incision should end at the papilla on each inter-proximal area of the tooth to be treated, but not all the way to the tip of the papilla, because at least 2 mm of gingiva must be left on each side of the flap to preserve blood supply. Afterwards a mid-facial intra-sulcu-

Table 1. ???????

Study year	Type of study (no. patients/recessions)	Surgical technique	Follow-up	% RC	% CRC
Lateral sliding flap					
Grupe & Warren (1956)	Case report (three patients)	Intrasulcular horizontal incision; full–partial thickness elevation; root planing; sutures	–	NR	NR
Grupe (1966)	?	Paramarginal horizontal incision; full–partial thickness elevation; root planing; sutures	?	NR	NR
Smukler (1976)	Case series (21 recessions)	Paramarginal horizontal incision; full–partial thickness elevation; root planing; sutures	9 months	72%	NR
Guinard & Caffesse (1978)	RCT (14 recessions)	As Grupe & Warren (1956)	6 months	69%	NR
Shiloah (1980)	Case report (one patient)	As Grupe & Warren (1956), Citric acid	6-9 months	NR	NR
Ricci et al. (1996)	RCT (20 recessions)	Intrasulcular horizontal incision; full–partial thickness elevation; tetracycline; sutures	12 months	62%	15%
Zucchelli et al. (2004)	Case series (120 recessions)	Paramarginal horizontal incision; mixed-thickness elevation; root planing; sutures	12 months	97%	80%
Zucchelli et al. (2012a,b)	RCT (25 patients) only upper molars	As Zucchelli et al. (2004)	12 months	74%	4%
Coronally advanced flap (single recession)					
Allen & Miller (1989)	Case series (37 recessions)	Triangular flap; partial-thickness elevation; root planing & citric acid; sutures	6 months	97%	84%
Pini Prato et al. (1992)	CCT (25 patients)	Trapezoidal flap; full–partial thickness elevation; root planing; sutures GTR	18 months	73%	NR
Trombelli et al. (1994)	Case series (15 patients)	As Pini Prato et al. (1992), GTR + tetracycline + fibrin glue	7 months	77.4%	37.5%
Wennström & Zucchelli (1996)	CCT (45 recessions)	Trapezoidal flap; partial-thickness elevation; root planing; sutures Postoperative atraumatic tooth brushing	24 months	97%	80%
Trombelli et al. (1996)	RCT split mouth (11 patients)	As Pini Prato et al. (1992), tetracycline	6 months	55%	18%
Trombelli et al. (1996)	RCT split mouth (11 patients)	As Pini Prato et al. (1992), tetracycline + fibrin glue	6 months	65%	9%
Zucchelli et al. (1998)	RCT (18 patients)	As Pini Prato et al. (1992) GTR (bioadsorbable barrier)	12 months	85.7%	39%
Zucchelli et al. (1998)	RCT (18 patients)	As Pini Prato et al. (1992) GTR (non-resorbable barrier)	12 months	80.5%	28%
Pini Prato et al. (1999)	RCT split mouth (10 recessions)	As Pini Prato et al. (1992) No root planing but polishing	3 months	89%	50%
Pini Prato et al. (1999)	RCT split mouth (10 recessions)	As Pini Prato et al. (1992) (Root planing)	3 months	83%	40%
Baldi et al. (1999)	Case series (19 patients)	As Pini Prato et al. (1992) Flap thickness: 0.4–1.1 mm	3 months	82%	37%
Baldi et al. (1999)	Case series (eight patients)	As Pini Prato et al. (1992) Flap thickness ≥0.8 mm	3 months	98.5%	87.5%
Modica et al. (2000)	RCT split mouth (12 recessions)	As Pini Prato et al. (1992) EDTA+EMD	6 months	91.2%	64%
Pini Prato et al. (2000)	RCT split mouth (11 patients)	As Pini Prato et al. (1992) Flap with tension	3 months	78%	18%
Pini Prato et al. (2000)	RCT split mouth (11 patients)	As Pini Prato et al. (1992) Flap without tension	3 months	87%	45%
Berlucchi et al. (2005)	Case series (19 patients) (REC: < 4 mm)	As Pini Prato et al. (1992) EDTA+EMD	12 months	94.7%	89.5%
Berlucchi et al. (2005)	Case series (11 patients) (REC: > 4 mm)	As Pini Prato et al. (1992) EDTA+EMD	12 months	85.8%	36.4%
De Sanctis & Zucchelli (2007)	Case series (40 patients)	Trapezoidal flap; split-full-split elevation; root planing; sutures	12 months	98.6%	88%
De Sanctis & Zucchelli (2007)	Case series (40 patients)	Trapezoidal flap; split-full-split elevation; root planing; sutures	36 months	96.7%	85%
Santamaria et al. (2007)	Case report (1 patient)	As Pini Prato et al. (1992) NCCL treated with RMGI	6 months	NR	NR
Lucchesi et al. (2007)	RCT (20 patients)	As de Sanctis & Zucchelli (2007) NCCL treated with RMGI	6 months	72%	15%
Lucchesi et al. (2007)	RCT (19 patients)	As de Sanctis & Zucchelli (2007) NCCL treated with MRC	6 months	74%	16%
Santamaria et al. (2008)	RCT split mouth (19 patients)	As Pini Prato et al. (1992) NCCL treated with RMGI	6 months	88%	NR
Santamaria et al. (2009)	RCT split mouth (16 patients)	As Pini Prato et al. (1992) NCCL treated with RMGI	24 months	81%	NR
Santana et al. (2009)	RCT split mouth (22 recessions)	As de Sanctis & Zucchelli (2007)	6 months	84%	67%
Zucchelli et al. (2009a,b)	RCT split mouth (11 patients)	As de Sanctis & Zucchelli (2007) curets	6 months	95%	82%
Zucchelli et al. (2009a,b)	RCT split mouth (11 patients)	As de Sanctis & Zucchelli (2007) Ultrasonic	6 months	84%	55%

Table 1. (continued)

Study year	Type of study (no. patients/recessions)	Surgical technique	Follow-up	% RC	% CRC
Cortellini et al. (2009)	Multicentre RCT (43 patients)	As Pini Prato et al. (1992)	6 months	NR	37%
Pini Prato et al. (2011)	RCT split mouth (nine recessions)	As Pini Prato et al. (1992) No root planing but polishing	14 years	NR	56%
Pini Prato et al. (2011)	RCT split mouth (nine recessions)	As Pini Prato et al. (1992) Root planing	14 years	NR	33%
Ozturan et al. (2011)	RCT (37 recessions)	As de Sanctis & Zucchelli (2007) LILT	12 months	NR	70%
Jepsen et al. (2013)	Multicentre RCT split mouth (45 patients) All recessions	As de Sanctis & Zucchelli (2007)	6 months	72%	31%
Jepsen et al. (2013)	Multicentre RCT split mouth (35 patients) REC >3 mm	As de Sanctis & Zucchelli (2007)	6 months	66%	17%
Coronally advanced flap (multiple recessions)					
Zucchelli & de Sanctis (2000)	Case series (74 recessions) (22 patients)	Envelope flap (lateral approach); split-full-split elevation; root planing; sutures	12 months	97% (rec)	88% (rec) 73% (pat)
Zucchelli & de Sanctis (2007)	Case series (25 recessions) (6 patients)	Envelope flap (frontal approach); split-full-split elevation; root planing; sutures	12 months	97% (rec)	89% (rec) 67% (pat)
Zucchelli et al. (2009a,b)	RCT (45 recessions) (16 patients)	Trapezoidal flap with releasing incisions (lateral approach); Split-full-split elevation; root planing; sutures	12 months	92% (rec)	78% (rec) 44% (pat)
Zucchelli et al. (2009a,b)	RCT (47 recessions) (16 patients)	As Zucchelli & de Sanctis (2000)	12 months	97% (rec)	89% (rec) 75% (pat)
Aroca et al. (2009)	RCT split mouth (67 recessions) All recessions	Envelope flap (lateral approach); split-full-split elevation; root planing; suspensory sutures	6 months	91%	75%
Aroca et al. (2009)	RCT split mouth (20 recessions) Upper-anterior recessions	Envelope flap (lateral approach); Split-full-split elevation; root planing; suspensory sutures	6 months	100%	100%
Ozcelik et al. (2011)	RCT (78 recessions)	Envelope flap (lateral approach); split-full-split elevation; root planing; button sutures	6 months	96% (rec)	85% (rec)
Coronally advanced flap (two step procedures)					
Bernimoulin et al. (1975)	Case series (41 recessions)	Trapezoidal flap;full–partial thickness elevation; root planing; sutures	12 months	75%	44%
Guinard & Caffesse (1978)	RCT (14 recessions)	As Bernimoulin et al. (1975)	6 months	64%	NR
Liu & Solt (1980)	Case series (nine recessions)	As Bernimoulin et al. (1975), + citric acid	2 months	59%	NR
Tenebaum et al. (1980)	Case series (34 recessions)	As Bernimoulin et al. (1975)	12 months	65%	20.5%
Pini Prato (1992)	CCT (25 patients)	As Bernimoulin et al. (1975)	18 months	72%	NR
Zucchelli & de Sanctis (2013)	Case report (two patients)	As de Sanctis & Zucchelli (2007)	–	NR	NR
Semilunar flap					
Sumner (1969)	Case report (one recession)	Semilunar incision; partial thickness; root planing; sutures	–	NR	NR
Tarnow (1986)	Case series (20 recessions)	Semilunar incision; partial thickness; root planing; no sutures	–	NR	NR
Marggraf (1985)	Case series (55 recessions)	Horizontal incision; partial thickness; root planing; sutures	24 months	72%	54.5%
Romanos et al. (1993)	Case series (75 recessions)	As Marggraf (1985)	5–8 years	NR	24%
Bittencourt et al. (2007)	RCT split mouth (15 recessions)	Semilunar incision; partial thickness; root planing; surgical adhesive	6 months	90%	67%
Sorrentino & Tarnow (2009)	Case report (one patient)	As Tarnow (1986)	6 months	100%	100%
Santana et al. (2009)	RCT split mouth (22 recessions)	As Tarnow (1986)	6 months	42%	9%

lar incision is made, to allow a coronal movement of the marginal tissue.

The DLBF (Margraff et al. 1985, Romanos et al. 1993) differs from the SF because a horizontal incision is made, parallel to the mucogingival line at a distance of 10–15 mm from the vestibulum, to produce a wider bridging flap ensuring blood supply.

The procedure seems to be effective in treating shallow recessions. However, a recent study (Santana et al. 2010) comparing SF and CAF, has indicated that the CAF is a more reliable technique, yielding to more predictable results when CRC is the aim of the treatment (Table 1). Differences in the blood supply between the two techniques may in part explain the different outcomes. Indeed rather than incisions parallel to the vascular axis and a flap base larger than the coronal part, the horizontal incision of the SF interrupts the vascular supply to the gingival margin.

Some unfavourable local anatomical conditions such as, the absence of KT apical to the recession defect, the presence of gingival cleft extending to the alveolar mucosa, the marginal insertion of frenuli and the presence of a very shallow vestibulum may render the CAF unfeasible. In such situations, the clinician could take the KT located laterally to the recession defect into consideration to evaluate the possibility of performing a LPF.

This surgical technique was first described by Grupe & Warren (1956), to provide a satisfactory solution to a gingival recession problem in lower incisors. Briefly, this flap design used the entire KT of the tooth adjacent to the one presenting the recession, thus exposing the donor tooth to a high risk of recession. To reduce this risk, the same author (Grupe 1966) proposed a modification of the incisions thus maintaining a band of KT, reducing the risk of donor tooth recession. Such technique provided a satisfactory solution in the treatment of localized gingival recession (Smukler 1976, Guinard & Caffesse 1978, Ricci et al. 1996) (Table 1).

More recently, Zucchelli et al. (2004) proposed a modification to the design of the LPF, incorporating elements of the CAF into the design. Essentially, the recipient bed was increased to reach a width of 3 mm on each side of the recession to be treated to improve the stabilization and the vascular connection of the sliding flap. Moreover, the design of the flap was encompassed between two parallel vertical incisions and a marginal semilunar one. This technique was recently compared to a CTG in a RCT in the treatment of gingival recession at the buccal aspect of upper first molars (Zucchelli et al. 2012a). The authors concluded that RC and high aaesthetic scores can be achieved by both techniques, with no statistically significant difference between them (Table 1).

When compared to the Grupe & Warren (1956) technique, where the flap has a trapezoidal incision and thus a large base, the Zucchelli et al. (2004) is mesio-distally smaller while the parallel incisions help the flap's lateral movement, eliminating the distal tension. One sub-marginal horizontal bevelled incision connects the two vertical incisions, ensuring the stability of the marginal tissue in the donor tooth.

Despite this, the data from literature do not seem to indicate that the LPF is a highly predictable and effective RC surgical procedure in comparison with the CAF (Table 1).

Other pedicle flaps with less scientific support or unfavourable results have been described in literature. In particular, the double papilla flap (DPF) (Cohen & Ross 1968) that essentially consists in two LPF designed on the papillae adjacent to the recession. The design of the flap consists in a short horizontal incision in the coronal portion of the papilla and a vertical incision up to the alveolar mucosa with a short cut back designed to ensure the necessary mobility towards the midline of the tooth to be treated. The two papillae are then sutured to each other over the midline of the root exposure. Stability of the flap is warranted only by the marginal overlapping of the two papillae that are excised with a reciprocal bevelled incision. The flap's extremely small anchorage area (the bevelled areas), the position of its most critical area (the suture of the two vertical incisions) on an avascular root and in an area of maximum tension (due to the root convexity), may explain the rather scarce application over time.

Pedicle flaps have also been designed in a two-stage procedure to increase the stability of the coronal position by incrementing the amount of KT.

Bernimoulin (1975) who first described a CAF, used a two-stage approach: a FGG was positioned apically to the mucogingival line and, in a second stage the entire complex was moved coronally over the root dehiscence. The rationale for this surgery was that by increasing the dimension and thickness of the KT, the flap would benefit from an increased stability with less postoperative shrinkage.

Results described by the author were encouraging, showing a good percentage of RC (Table 1). Recently Zucchelli & de Sanctis (2013) have proposed a modification to the technique. By reducing the dimension of the graft used to be comparable with the existing KT of teeth adjacent to the recession, the aesthetic outcome of the surgical procedure has greatly improved while, however, maintaining great limitations to its application due to the two-step procedure.

Multiple recessions

Gingival recessions are very seldom localized to a single tooth, but more often they affect multiple adjacent teeth. In this case, to minimize the number of procedures and patient discomfort, it is advisable to treat all the recessions by means of a single surgery.

To treat multiple (more than two) recession defects, Zucchelli & de Sanctis (2000) have introduced a modification to the CAF. The design is a modified envelope flap that is designed with oblique submarginal incisions in the area of the papillae without intra-sulcular incisions; the tissue at the bottom of the recession is left untouched by the knife and the sulcular area is opened with a periostium elevator. According to the authors, this approach may reduce the risk of damage to the marginal area that in turn will reduce the risk of inflammation and thus recession. Also, the absence of vertical releasing incisions should improve the trophism of the entire flap avoiding damage to the lateral

distribution of the vascular supply while eliminating the risk of scars on the tissue. Indeed, Zucchelli et al. (2009a) investigated the influence of vertical releasing incisions to approach multiple recession type defects in combination with a CAF. Although the flap's design did not influence the patient's perception of the results the chance to obtain CRC was higher in the group without vertical releasing incisions (Table 1).

A "frontal approach" of the same flap was proposed for multiple recessions in the maxillary anterior teeth (Zucchelli & de Sanctis 2007). The design of this flap is limited to the oblique incision of the inter-dental papillae with the exception of the central papilla that is always maintained intact. By avoiding all vertical releasing incisions and maintaining the integrity of the central papilla the authors obtained good aesthetic results and a satisfactory amount of RC (Table 1).

Flap elevation

Pedicle flaps, whether laterally moved or coronally advanced, can either have a partial thickness, a full thickness, or a combined elevation.

One of the essential features of the original LPF (Grupe & Warren 1956) was the elevation of a full-thickness flap involving the entire marginal gingiva, making bone denudation at the donor site part of the operation. This may create permanent bone loss and consequently, gingival recession. To avoid these problems many modifications to the original procedure, as well as new techniques have been proposed. Staffileno (1964) proposed the use of a partial-thickness flap, instead of a full-thickness one to cover the root exposure. Ruben et al. (1975) introduced a mix-thickness flap, which consisted in a full-thickness flap performed close to the recession defect to cover the exposed root, and a split-thickness flap laterally to the full-thickness one, to cover the bone exposed at the donor site of the full-thickness flap. The different thicknesses during flap elevation (greater in the central area –i.e. the avascular root surface- than in the more peripheral portions of the flap –i.e. the surgical papillae-) represented one aspect of the technique proposed by Zucchelli et al. (2004). Indeed, the surgical papillae were elevated keeping the blade almost parallel to the long axis of the tooth, while the central portion of the flap was elevated with greater thickness using a blade with a 45° inclination with respect to the underlying bone surface. In this latter area, great care was taken to leave the periosteum as a protection of the underlying bone. Furthermore, the authors introduced the elimination of all muscle insertions from the thickness of the flap, to allow a more coronal advancement of the laterally moved flap. This main modification was carried out keeping the blade parallel to the external mucosal surface.

The idea of a mixed-thickness flap was recently adopted for both multiple (Zucchelli & de Sanctis 2000) as well as single (De Sanctis & Zucchelli 2007) recessions treated by a CAF. A full-thickness flap up to the mucogingival junction, followed by a partial-thickness dissection apically of the junction, was used by Pini Prato et al. (1992) in a RCT comparing guided tissue regeneration (GTR) and a two-step procedure for a CAF. In this approach, the portion of the flap moved over the previously exposed avascular root surface includes the periostium, thus conferring a greater thickness, and better opportunity for achieving RC (Baldi et al. 1999), compared to a split-thickness flap obtained by a sulcular incision (Bernimoulin 1975, Allen & Miller 1989).

Root preparation

Since the first attempts to treat gingival recession (Grupe & Warren 1956, Cohen & Ross 1968, Sumner 1969, Bernimoulin 1975), treatment (mechanical and/or chemical) of the exposed root surface has been a fundamental step in surgical procedures.

Mechanical root instrumentation aimed at smoothing out irregularities and grooves of the root surface (Wennstrom 1996), reducing the convexity of the root and the mesio-distal distance between periodontal spaces (Holbrook & Ochsenbein 1983, Miller 1985a,b), minimizing cementum toxicity (Bertrand & Dunlap 1988) and removing root caries lesions (Fourel 1982, Miller 1983). However, some of the expected goals of root planing were recently questioned to be essential in root-coverage surgical procedures. Pini Prato et al. (1999) reported that the same clinical results could be achieved by polishing the exposed root without the need of root planing. Nevertheless, assessing results after 14 years of follow-up (Pini Prato et al. 2011), the two approaches showed different trends: polishing showed a greater recession reduction in sites with baseline KT widths >3 mm, while root planing resulted in a greater recession reduction in sites with baseline KT width <3 mm. In contrast, no differences between the two mechanical treatments (courets and ultrasonic) were observed by Zucchelli et al. (2009b). Patients with high levels of oral hygiene are normally associated with the presence of low levels of plaque in clinically healthy gingiva and thus clean root surfaces. This may in part explain the absence of differences. Therefore, more conservative and less time-consuming approaches for root instrumentation could be suggested (AAP 2000). Furthermore, the importance of vigorous root planing in mucogingival procedures has been questioned because it does not seem effective in reducing the convexity of the root (Saletta et al. 2005).

However, the presence of smooth irregularities and grooves on the root surface, such as decay or cervical lesions, might present difficulties in identifying the CEJ (Zucchelli et al. 2006) and impair the stabilization of the flap (Cortellini & Pini Prato 2012). Therefore, some authors have proposed the reconstruction of the CEJ (Zucchelli et al. 2006) or the abraded root surface (Lucchesi et al. 2007, Santamaria et al. 2007) with resin glass ionomer composite, obtaining RC improvement without damaging the periodontal tissues (Santamaria et al. 2008, 2009).

In combination with mechanical treatment, several authors suggest the use of different chemical agents, to detoxify, decontaminate and demineralize the root surface (Oles et al. 1988).

Various acids have been used, including citric and phosphoric acids (Register & Burdick 1975) and ethylenediaminetetraacetic acid (EDTA)

(Lasho et al. 1983), to remove the smear layer produced by root instrumentation, **to** expose the collagen fibrils of the dentin matrix, to facilitate the formation of new connective tissue attachment, and to remove cytopathic substances from infected cementum that inhibit human gingival fibroblast growth, with subsequent induction of cementogenesis processes. (Otomo & Sims 1979, Liu & Solt 1980, Shiloah 1980, Miller 1982). Variable results have been reported in terms of amount and stability of RC (Liu & Solt 1980, Shiloah 1980) (Table 1).

Tetracycline-hydrochloric acid (TTC-HCl) has also been used, because pre-clinical studies indicated that it might regulate the absorption of plasma proteins, enhance blood clot adhesion and stimulate deposition of collagen against the root surface (Wikesjö et al. 1992). Bouchard et al. (1997) indicated that topical application of TTC-HCl solution has a clinical effect comparable to that of citric acid in RC (Table 1).

Fibrin glue (FG) has been used in the treatment of buccal recession defects, resulting in significant recession depth reduction and clinical attachment gain (Trombelli et al. 1994, 1995, 1996) (Table 1).

However, a recent systematic review (Cheng et al. 2007) on the efficacy of different root conditioning procedures in CAF, revealed that clinical outcomes for RC do not depend on their use. No additional benefit had been demonstrated as a result of the use of these products, making such procedures unpredictable.

On the other hand, the same review reported that the application of enamel matrix derivatives (EMD) on denuded root surfaces, treated with the CAF procedure, significantly increased the percentage of RC and attachment level when compared to the CAF alone and the CAF + chemical root surface conditioning procedures (Cheng et al. 2007).

The application of EMD may lead to the formation of a functional periodontal ligament, new cementum, and islands of condensing bone (McGuire & Cochran 2003), similar to that promoted by GTR (Cortellini et al. 1991a,b, Tinti et al. 1992, Pini Prato et al. 1992, Cortellini et al. 1993, Parma-Benfenati & Tinti 1998). However, even if GTR is a predictable technique, CRC occurs on average less than 50% of the time when compared to CAF + EMD (Roccuzzo et al. 2002). Basically, CAF + EMD is more time-saving and less technique-demanding when compared to GTR. The procedure of CAF plus EMD is associated with high predictabilities of RC (Table 1), similar to that obtained by the use of a CTG (Cairo 2008, Chambrone 2010b, Chambrone 2012) , although with less post-operative discomfort given the absence of the second surgical site used to harvest a graft from the palate (McGuire & Nunn 2003). Root surface conditioning is a prerequisite of the EMD protocol, as it improves the quality of the root surface before EMD application, by removing the smear layer and exposing the collagen fibres (Blomlof et al. 1997).

New techniques for the treatment of gingival recessions with CTG were used on the root surface with the purpose of bio-modifying it (Nd:YAG lasers) or removing the smear layer (Er:YAG laser) (Dilsiz et al. 2010a,b), due to promising in vitro and in vivo data (Walsh et al. 1996, Yu et al. 1996, Pinheiro et al. 2005, Tuby et al. 2006). However, the use of Nd:YAG lasers negatively affected the outcome (Dilsiz et al. 2010a), and the application of the Er:YAG laser did not enhance the results when compared with CTG alone (Dilsiz et al. 2010b). Only one study with a diode laser (Ozturan et al. 2011) demonstrated significantly higher percentages of CRC at the post-operative first year. However, the procedure requires a considerable amount of time and costs, making the justification of its use complicated with relatively few additional benefits.

Flap mobility

The passivity of the flap is an issue of paramount importance, in fact when tight sutures are positioned to overcome the residual tension of the flap, they may damage the residual vascular system reducing vessel patency and impairing neovascularization (Cortellini & Pini Prato 2012). Several factors, such as root prominence, recession depth/width, presence of frenula and vestibule depth, may influence flap mobility and thus the passive advancement of the flap towards the CEJ. An angiographic study on humans demonstrated that the best clinical outcomes in terms of RC arise from flaps passively adapted and sutured without tension over denuded roots (Mormann & Ciancio 1977). This finding was confirmed by a RCT (Pini Prato et al. 2000) comparing the CAF procedure with or without tension before suturing. It was reported that minimal flap tension (ranging from 0.0 to 0.4 g) favoured a higher RC percentage, while higher tension of the flap (ranging from 4 to 7 g) was associated with lower percentages of RC. The original lateral/coronal positioned flap techniques (Grupe & Warren 1956, Bernimoulin et al. 1975, Allen & Miller 1989) provided undermining excisions to lay the flap flat, separate it from the periosteum, and to facilitate lateral/coronal displacement. Nevertheless, the muscular layer that remains within the flap may become a source of tension during the healing process. To overcome such tension, an important modification of the surgical technique was the mixed-thickness approach as described by Zucchelli & de Sanctis (2000), Zucchelli et al. (2004) and De Sanctis & Zucchelli (2007), derived from the first observation that the lateral/coronal passive displacement of the flap could not be achieved by means of only periosteal incisions. Indeed, a superficial-layer split-thickness flap (Greenwell et al. 2004) was introduced to eliminate muscle insertions included within the flap as described above (see "2. Flap elevation" for details) providing a passive coronal stabilization of the flap.

Flap stability and suturing

The stability of a flap depends on its capability of maintaining the position reached at the end of surgery and can be considered adequate when its marginal portion is able to passively reach a level coronal to the CEJ of the tooth with a recession defect, even without sutures, and maintain its position at the end of

the healing processes (Pini Prato et al. 1999, 2005, Cortellini & Pini Prato 2012).

The importance of flap stabilization has been demonstrated with superior results reported (Table 1) when flap anchorage was obtained via suturing (Marggraf et al. 1985, Romanos et al. 1993) or placement of surgical adhesive (Bittencourt et al. 2006, 2007), rather than in the original technique (Tarnow 1986).

Interrupted and suspensory sutures are the most commonly used suturing techniques reported in literature for both laterally and coronally moved flaps (Grupe & Warren 1956, Bernimoulin et al. 1975, Allen & Miller 1989). To facilitate the coronal displacement of the flap and to reduce the tension of the critical portion (i.e. the last coronal suture), suturing usually begins with two interrupted sutures in the most apical part of the vertical releasing incisions and then proceeds in a coronal direction, along the mesial vertical incision, with interrupted sutures, each of them directed in an apical-coronal direction (Grupe & Warren 1956, Bernimoulin et al. 1975, Allen & Miller 1989, Zucchelli et al. 2004, De Sanctis & Zucchelli 2007). Similarly, when an envelope approach is used to treat multiple recessions, the initial sutures stabilize the peripheral areas of the flap, the most distal and mesial surgical papilla, and then the suturing continues towards the central area (Zucchelli et al. 2000). The last marginal sling suture allows for a precise adaptation of the buccal flap over the exposed root surface and stabilizes every single surgical papilla over the inter-dental connective tissue bed (Zucchelli & de Sanctis 2000, Zucchelli et al. 2004, De Sanctis & Zucchelli 2007).

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

To prevent tissue collapse, Aroca et al. (2009) reported a new technique, which includes composite stops placed at the contact points of adjacent teeth and horizontal suspensory sutures over the inter-proximal spaces warranting a better stabilization of the flap margin above the CEJ during the first 2 weeks of wound healing.

More recently, orthodontic buttons applied to the facial side of the teeth were used, to guarantee the anchorage of the CAF for multiple recessions (Ozcelik et al. 2011) to be at least 3–4 mm coronal to the CEJ of all teeth at the end of surgery. Results of such technique lead to a statistically significant recession reduction compared to the CAF alone confirming that the more coronal the gingival margin after suturing, the greater the probability of achieving CRC.

Prognostic factors for CRC

Several factors may contribute to obtaining CRC with a good aesthetic appearance. The main objective of a periodontal plastic procedure is to strive for patient satisfaction (Zucchelli et al. 2011). Various studies have examined these factors, which can be classified as anatomical, patient and clinician factors.

Anatomical factors

Adjacent bone height and attachment level. In 1985, Miller described a classification of recession defects that took into consideration the anticipated RC that could be obtained. Gingival recessions were classified into four classes: in Class I and II, there is no loss of inter-proximal periodontal attachment and bone; in Class III, the loss of inter-dental periodontal support is mild to moderate; in Class IV, the loss of inter-proximal periodontal attachment is severe. Based on such classification, CRC was predictable only in Class I and II defects (Miller 1985a,b). Recent studies (Aroca et al. 2010, Cairo et al. 2012) demonstrate as CRC seems to be predictable also in Class III-type recessions. However, those studies consider a limited amount of patients and confirms are needed.

Adjacent papilla dimension. The papilla dimensions of affected teeth can be used as a valuable aid to predict the success of a future RC procedure, as during a periodontal plastic surgery the inter-dental papillae, once disepithelized, act as vascular beds where the soft tissues covering the root exposure are anchored and sutured (Zucchelli et al. 2006). Based on the results of different studies (Berlucchi et al. 2005, Zucchelli et al. 2006, Haghighati et al. 2009) there is a significant positive correlation between papilla height and the percentage of RC: in cases with a papilla height of 5 mm or greater, the future RC had been always 100%. Also papilla width (Haghighati et al. 2009) is positively correlated with the percentage of RC, because a narrow papilla could limit the extension of the horizontal incisions at the level of CEJ carried out during the procedure, meaning that the coronal area of the underlying bed cannot provide adequate blood supply for the flap in the healing process. However, these findings are in contrast with other studies (Saletta et al. 2001, Huang et al. 2005) that found CRC significantly more frequent in sites with lower height adjacent papilla. This could be explained by different measurement methods between studies, as in the latter the level of the CEJ of adjacent teeth had an influence on the level of papilla height.

Tooth rotation, tooth extrusion, occlusal abrasion and root prominence could modify the inter-dental papilla (e) height, even in the absence of inter-dental attachment and bone loss (Zucchelli et al. 2006).

Gingival thickness. Based on Huang et al. (2005), if initial thickness (measured at the attached mucosa) is >1.2 mm., then the chance of achieving 100% RC is higher. This is in agreement with another study (Baldi et al. 1999), reporting that CRC is related to tissue (measured at the alveolar mucosa) thicker than 0.8 mm.

Amount of KT. Even in absence of evidence, a CAF/LPF is selected only when a certain amount of residual KT is present apically/laterally to the root surface, as a statistically significant relationship between CRC and thick tissue (Huang et al. 2005) or large amounts of residual KT

(Allen & Miller 1989, Zucchelli et al. 2004) are shown.

Presence of non-carious cervical lesions (NCCL). The presence of NCCL that involve abrasion due to mechanical forces, corrosion and possibly abfraction, can lead to frequent mistakes in the localization of the anatomical CEJ on the tooth with the recession defect (Zucchelli et al. 2006). The predetermination of the clinical CEJ is critical, because might be used to evaluate RC outcomes of a given surgical procedure (when the anatomical referring parameter, i.e. CEJ, is lacking). The presence of an abrasion or a step is not correlated with a minor % of RC (Santamaria et al. 2008) and successful outcomes are shown when RC surgery is performed on a previously restored root surface (Lucchesi et al. 2007). Furthermore, a restorative/periodontal treatment of a cervical abrasion associated with gingival recession may improve final aesthetic outcomes (Zucchelli et al. 2011).

Defect size. Wider recession defects are considered a greater challenge than narrower ones (Jepsen et al. 2013) and root curvature may have an impact on the outcome of RC, as the avascular area is larger in prominent roots (Saletta et al. 2005). On the other hand, the effect of initial recession depth on the amount of RC remains controversial. Some literature reviews indicate that increased initial recession depth was associated with decreased in percentage of CRC or partial RC (Roccuzzo et al. 2002, Clauser et al. 2003, Nieri et al. 2009). However, some studies observed a greater reduction in recession in deep defects (Zucchelli et al. 1998, Zucchelli et al. 2000, Cortellini et al. 2009).

Tooth location. Although it was not statistically significant, the trend was that maxillary teeth achieved CRC more predictably than mandibular teeth (Trombelli et al. 1995, Huang et al. 2005, Aroca et al. 2007).

Patient factors

Age, gender, and race did not seem to influence the outcome of RC (Huang et al. 2005, Cortellini & Pini Prato 2012), even if few articles are present in literature to study such influences.

Smoking status. Smoking has been shown to negatively influence clinical results. Achieving CRC in smokers is less probable (Zucchelli et al. 1998, Martins et al. 2004, Chambrone et al. 2009).

Traumatic tooth brushing. Traumatic tooth brushing influences the development and progression of facial gingival recession (Rajapakse et al. 2007), but there is little evidence that changes in tooth brushing habits may be significant for long-term maintenance of the surgical procedure (Wennström & Zucchelli 1996, Zucchelli & de Sanctis 2005). In a 14-year long-term study on single gingival recessions treated by CAF (Pini Prato et al. 2011), the authors observed a relapse of the soft tissue margin, and speculated as it could be due to a resumption of traumatic tooth-brushing habits in patients with high standard of oral hygiene, even if they were included in a stringent maintenance protocol with recall visits every 4–6 months.

Plaque control. Even if facial gingival recessions often occur in patients with a high level of oral hygiene, there is scarce information on the influence of plaque control both at the early phases of healing as in the long-term maintenance of the surgically positioned margin (Zucchelli & de Sanctis 2005).

Factors related to operator

Operator learning curve. A surgeon's clinical experience is a potential factor that influences judgment, case selection and surgical skills (Huang et al. 2005, Pini Prato & Cortellini 2012). A consistent centre effect has been demonstrated in a recent multicentre RCT comparing the CAF and the CAF + CTG in the treatment of single recessions (Cortellini et al. 2009). The influence of individual surgical skills may explain variable outcomes obtained when different clinicians perform the same surgical procedure, as resulted in the systematic review (Cairo et al. 2008, Chambrone et al. 2010b, 2012).

Peri-implant plastic surgery

Similarly to teeth, the occurrence of facial soft tissue dehiscence is a common finding following implant-supported restorations in patients with a high standard of oral hygiene (Adell et al. 1986, Bengazi et al. 1996, Chang et al. 1999, Grunder 2000, Small & Tarnow 2000, Kan et al. 2003, Cardaropoli et al. 2006, Jemt et al. 2006, De Rouck et al. 2008, Evans & Chen 2008).

Several factors have been described to negatively influence the stability of the peri-implant mucosa of the facial aspect (Bengazi et al. 1996, Sorni-Broker et al. 2009, Nisapakultorn et al. 2010): local factors, affecting both soft (mucosal quality -keratinized or non-keratinized-, mucosal attachment -mobile or non-mobile-, mucosal thickness) and hard (facial bone crest level and thickness, inter-proximal bone crest level, level of first bone to implant contact) tissues; implant-prosthetic factors (micro and macrostructure of the implant neck, implant-abutment and prosthesis connection), and surgical-positioning factors (immediate or delayed, tridimensional positioning).

In addition to functional and health-related aspects, the visual appearance of implant-supported restoration is an important factor for clinical success in aesthetic sites (Benic et al. 2012), and the peri-implant mucosa has a significant influence on the overall aesthetic result (Chang et al. 1999). Consequently, when a perimplant soft tissue recession occurs, the same surgical coverage technique proposed for recession around teeth may be indicated. However, while different RC surgical procedures have been described over the years with well reported results in literature (Cairo 2008, Chambrone et al. 2010b, 2012), soft tissue dehiscence coverage (STDC) around endosseous implants has been studied much less.

Only a limited number of studies describe the use of the CTG (Shibli et al. 2004, Lai et al. 2010, Burkhardt et al. 2008, Zucchelli et al. 2012b, 2013, Roccuzzo et al. 2013) or the acellular dermal matrix graft (Mareque-Bueno 2011) techniques to correct soft tissue defects on implant sites. Although a description of such

techniques is not the aim of this article, some important biological considerations can arise, to explain the flap approaches used.

It is well known that a different anatomy is present between teeth and implants: the absence of a supracrestal fibre insertion into the cementum and of a periodontal ligament, with its dense vascular network, characterizes the peri-implant mucosa. The lack of such a vascular system, responsible for the blood supply, might explain the shrinkage of the soft tissues observed following a traditional CAF procedure with CTG techniques, resulting in 66% and no CRC of tissue dehiscence at 6 months (Burkhardt et al. 2008). Recently, the same technique led to a 89.6% of mean coverage, with a complete coverage in 56.3% of the cases and a significant improvement of aesthetic analysis (Roccuzzo et al. 2013) In this study, however, a low number of patients were treated and baseline recessions were minimal (mean: 2 mm).

A modified surgical and prosthetic management of clinical cases has been proposed by Zucchelli et al. (2012b, 2013), obtaining better outcomes. One month before surgery the implant crown restoration is removed and the underlying abutment is milled to reduce, if present, implant proclination and to eliminate shoulders or chamfers, allowing the inter-dental soft tissue to occupy the space previously occupied by the metal. During surgery, the absence of the prosthetic crown allows the extension of the disepitelization of such inter-dental soft tissue in the occlusal and palatal direction, improving vascular exchange and allowing for both a more coronal placement of the graft and the covering flap. At the end of surgery the provisional crown is reduced to avoid contact with the soft tissue, and is provisionally cemented, to allow for an undisturbed healing without the interference of the pre-operative crown-abutment interface. Only 8 months later a definitive impression is made, to select the final shape of the abutment, according to the axis of the implant and the soft tissue around it, and to perform the definitive restoration.

Such modifications both in design of the flap and execution of surgical and prosthetical steps, might have contributed to improving the STDC outcome. In fact an average STDC of 96.3% was obtained, with a complete coverage observed in 75% of the treated sites. These results are more successful than those reported by Burchardt et al. and Roccuzzo et al., and similar to those reported for the treatment of class I and II gingival recession with the CTG technique (Cairo et al. 2008, Chambrone et al. 2010b, 2012).

Conclusions

Different surgical options are available when performing periodontal plastic surgery, resulting in a great variability in clinical outcomes.

Some critical elements are evident in flap design and execution, whose aim is to achieve CRC:

- The dimension of the vascular support appears to be a key element when positioning a flap over an avascular area like the root surface. Enlarging the base of the flap and/or the recipient side may have a role in improving tissue tropism and in turn in obtaining better RC. However, at the moment there is no evidence available given that no study has compared different designs in a controlled setting.
- The thickness of tissue positioned over the denuded root seems to be important in achieving CRC. One study indicates a direct relationship between tissue thickness and RC.
- Flap stability in a position coronal to the CEJ at the end of the surgical procedure is critical. Several techniques have been proposed to obtain this result but their relative effectiveness has not been tested as of yet.
- The relative influence of mechanical or chemical treatment of the root surface to achieve CRC is questionable. Although all the authors suggest that the root surface should be detoxified, some evidence indicates that there could be no need for a thorough root planing, thus limiting root debridement to the superficial layer or to solely polishing the root surface.
- The use of EMD on root surfaces following the application of EDTA, prior to flap positioning, significantly increases the percentage of RC and attachment level.
- Compliance to a supportive care programme seems to have a predominant role in the long-term maintenance of obtained results. On the other hand the influence on marginal tissue stability of a non-traumatic tooth brushing technique following a flap procedure has not yet been demonstrated in a controlled setting.

Although it is not the aim of this article, it was possible to denote some critical elements from the analysis of literature when CRC is the objective of the treatment:

- Smoking status and operator surgical skills are critical to achieving CRC.
- The pre-surgical determination of the CEJ is of paramount importance for the evaluation of obtained results. Several studies do not have evidence of the CEJ as an inclusion criteria, and this fact may generate doubts in interpreting surgical results. From a clinical stand point, when the anatomical CEJ is not present due to abrasion or abfraction, the clinical position of the CEJ should always be evaluated

Bone height and attachment level, papillae dimension, tooth rotation, tooth extrusion, occlusal abrasion and root prominence, amount of KT, tissue thickness, defect size and location of the tooth are anatomical factors that may modify the choice of the surgical technique.

The possibility of using pedicle flaps to achieve complete soft tissue coverage of facial implant dehiscence has not been investigated.

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Clinical Relevance

Scientific rationale for the study: Numerous flap approaches have been proposed and tested for the treatment of facial gingival recessions and peri-implant soft tissue dehiscences, but a critical analysis of such surgical procedures aimed at identifying critical elements in design and execution is lacking.
Principal findings: Pedicle flaps analysed in the literature to solve facial gingival recessions are essentially the laterally positioned and the coronally advanced flap or their modifications. The dimension and the thickness of the flap, its stability and suturing in a position coronal to the cemento-enamel junction, and the use of enamel matrix derivates on the root surface seems to be critical in obtaining complete root coverage. No studies have investigated the possibility of using pedicle flaps alone to achieve complete soft tissue coverage of facial implant dehiscence.
Practical implications: Different elements are critical when performing laterally positioned and coronally advanced flap or their modifications with the aim of covering denuded roots. Conversely, the possibility of using pedicle flaps alone to cover facial implant dehiscence is not present.