



# Microscope-Assisted Preprosthetic Surgery

Kotaro Nakata

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## Abstract

In recent years, esthetic dentistry has continued to evolve with our patients' demands. In addition to the harmony of facial features and smiles, it has become possible to achieve extremely advanced esthetic results including improving soft tissue quality and quantity. For that reason, we need to have the option of surgical management of soft tissues applying periodontal plastic surgery (PPS) when performing prosthetic restoration. As a pretreatment for prosthetic restoration, a soft tissue with the required amount and morphology around the implant and natural teeth is constructed in harmony with the surrounding tissue. Diagnosis and pre-operative examinations are very important before the treatments. Clinical parameters include the periodontal phenotype, the amount of keratinized gingiva, position of gingival margin, the height of interdental papilla, etc. Applying PPS options to gain esthetics and long-term function after prosthetic restoration are often needed. The application of microsurgery is an effective method because

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K. Nakata (✉)  
Kyoto Prefectural University of Medicine, Kyoto, Japan  
e-mail: [info@nakata-dental.com](mailto:info@nakata-dental.com)

these PPS procedures requires extremely delicate and precise surgical procedures. This chapter presents practical clinical examples and verifies the advantages of microsurgery.

### Keywords

Microsurgery · Preprosthetic surgery · Periodontal plastic surgery · Prosthodontics

## 1 Introduction

In this chapter, we will primarily discuss the effectiveness of using operating microscope (OM) for preprosthetic surgery (PPS) in the esthetic area. PPS is applied not only to natural teeth but also to teeth that have already or will undergo prosthetic restoration. In the 1980s, Schallhorn introduced mucogingival surgery as a preprosthetic procedure [1]. Recently, various periodontal plastic surgeries, which are more frequent and diverse, have been applied as preprosthetic treatment. These procedures help to establish adequate amount of sound tooth structure, supracrestal attachment tissues (SAT), keratinized mucosa, symmetrical gingival margin level, regeneration of papillae, etc. for oral health, comfort, function, and esthetics [2]. A multifaceted approach and close collaboration between periodontists and prosthodontists are required [3]. In recent years, new dental technology and materials have continued to evolve. We have entered an era in which not only the esthetics of restorations but also the esthetics of the surrounding tissue is required. Microsurgery allows for accurate and delicate tissue handling in these transitional areas such as gingival margins and papilla tissue, potentially resulting in improved wound healing and clinical outcomes. This chapter will demonstrate how microscope can be used in four main preprosthetic periodontal plastic procedures, including free gingival graft (FGG)/connective tissue graft (CTG), open/closed periodontal plastic surgery techniques ± CTG, crown lengthening, and papilla regeneration (Table 1).

## 2 Donor Site Evaluation and Harvesting Techniques for Free Gingival Graft (FGG)/Connective Tissue Graft (CTG)

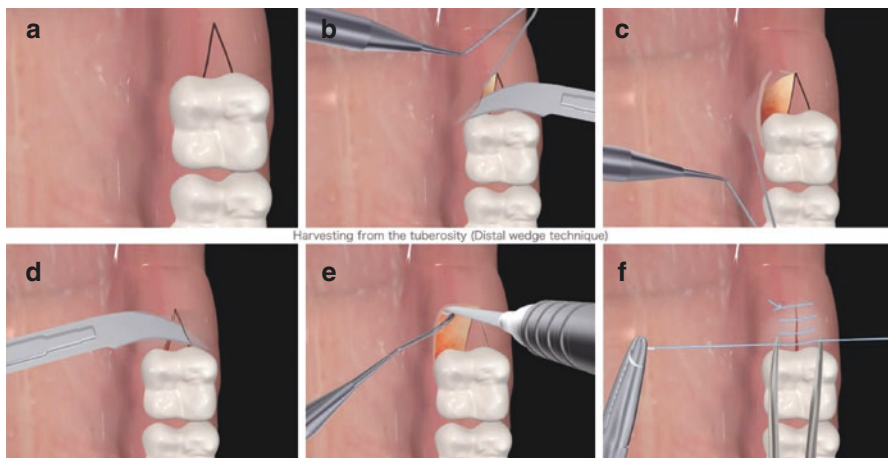
A positive clinical outcome of FGG/CTG harvesting requires a thorough understanding of the anatomy of the donor site, tissue integration, and vascular

**Table 1** The four primary procedures and indications related to preprosthetic surgery

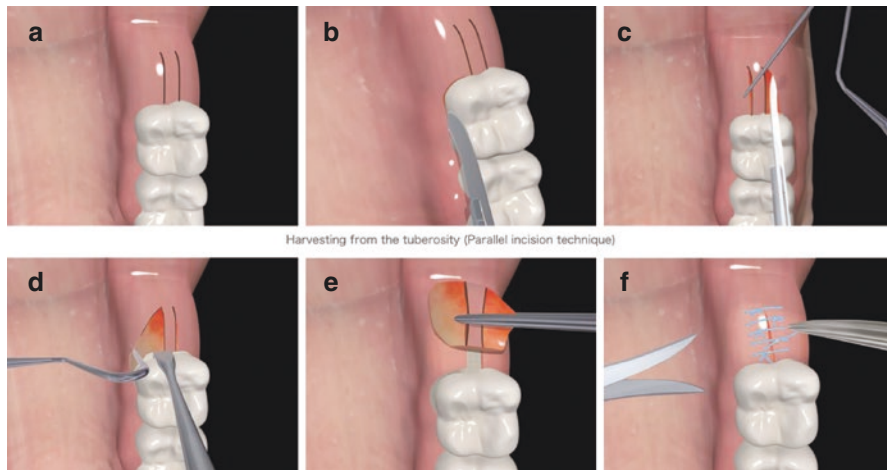
Procedures	Indications
Free gingival graft (FGG)/connective tissue graft (CTG)	To increase keratinized mucosa width; may be used for root coverage
Open/closed periodontal plastic surgery techniques ± CTG	Root coverage, increase tissue thickness
Crown lengthening	To increase tooth structure; to level gingival margin; to create SAT space
Papilla regeneration	To regenerate interdental papilla

regeneration processes. Basically, the donor site can be from the hard palate or from the maxillary tuberosity. The maxillary tuberosity, compared to the hard palate, may be away from the branches of the greater palatine vessels, thus may be safer. Additionally, patients in general experienced less postoperative discomfort and complications [4, 5]. The tuberosity tissues are thicker and may maintain the volume better. However, Zuhr et al. [6] suggested that the connective tissue from the maxillary tuberosity is denser, and richer in collagen than the palatal tissue. Therefore, it may negatively affect wound healing and is more likely to cause necrosis. Even though postoperative absorption is low, it is necessary to pay attention to the blood supply to prevent necrosis during transplantation. The collection method is the the same as the distal wedge method, that is to thin the tissue at the maxillary tuberosity. The incision design could be in triangular shape (Fig. 1) or rectangular shape (Fig. 2). If the second molar is present, it may not be a suitable donor site due to the lack of the mesial-distal length of the maxillary tuberosity. The presence of a third molar poses a challenge for collection. If the patient has small mouth opening and limited access, soft tissue collection at this location can be difficult.

Harvest from the palatal mucosa is in general a preferred choice as a donor site because it is suitable to almost all patients. The palatal mucosa has a connective tissue layer covered by keratinized epithelium, immediately below which is a submucosal layer of fat and glandular tissue between the palatine bone. The thickness of the palatal mucosa varies from patient to patient, but it



**Fig. 1** Triangular-shaped incision for tissue harvest from the tuberosity. (a) Measure the gingival thickness in the tuberosity by bone sounding and mark the gingiva with the shape of a triangle. (b) Using a 12D scalpel from a triangle, remove the epithelium into a trapezoidal shape to expose connective tissue. (c) The state where the formation of the palatal mucosa is completed. (d) Subsequently, the buccal side is formed in the same manner. (e) Separate connective tissue from bone with an elevator. (f) After the graft has been collected, it is sutured, and the wound is closed. The epithelium remaining on the graft is removed by trimming

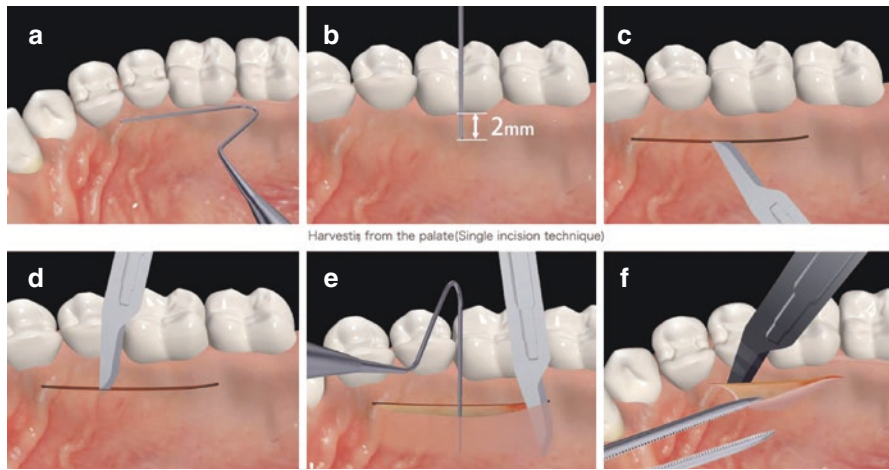


**Fig. 2** Rectangular-shaped incision for tissue harvest from the tuberosity. (a) Mark the gingiva with two parallel incision lines (2–3 mm wide) that reach the alveolar mucosa. (b) Line the parallel incision line and widen the incision in the connecting 7th gingival sulcus. (c) Using a 12D scalpel, cut the subepithelial area into a trapezoidal shape from the parallel incision line to the palate and buccal side to form a connective tissue graft. (d) The graft is separated from the bone using a periosteal elevator. (e) The epithelial part of the collected graft is trimmed and transferred to the recipient site. (f) Close the wound using intermittent or simple continuous sutures

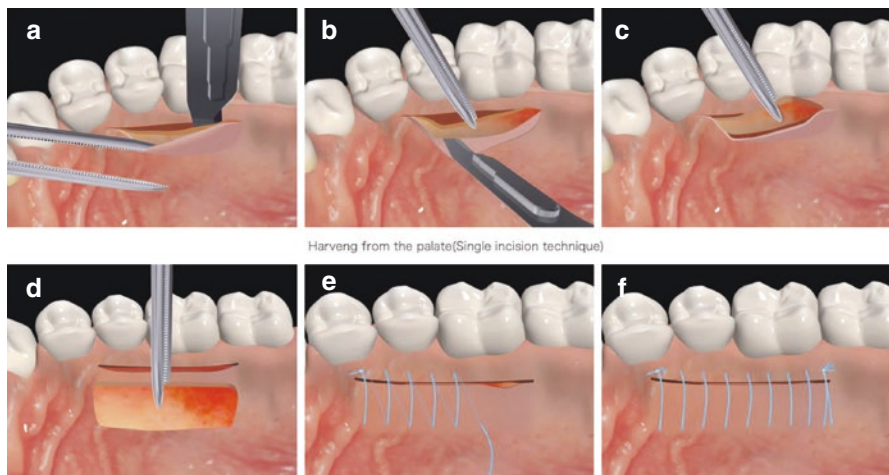
is desirable that the full thickness is 3 mm or more to be usable as a donor location. Location wise, the area from the 2nd premolar to 2nd molar might be suitable, in contrast to the 1st premolar site, where there is insufficient collagen tissue and thicker adipose and glandular tissues [7]. Various harvesting techniques have been developed over the past few decades. Edel [8] showed the trapdoor technique to collect CTG. This method is relatively easy to harvest CTG and is still used today, but it tends to cause partial necrosis on the epithelial side because the vertical incisions compromised the blood flow. Langer and Langer [9] presented a double-incision approach without a vertical incision. Hurzeler [10] proposed a single-incision technique that heals quickly and causes less discomfort and pain after surgery (Figs. 3 and 4). Another method is to first collect FGG, followed by de-epithelialization extra-orally. Table 2 summarized the advantages and disadvantages of the abovementioned techniques for harvesting soft tissues from the palate.

### 3 Root Coverage Procedures: Recipient Site Consideration and Preparation

Table 3 summarizes the two general surgical procedures, open and closed techniques for PPS in consideration for the recipient site preparation [11]. As a flap design for PPS, the method of performing tension reduction using a conventional envelope



**Fig. 3** Single incision technique for palatal tissue harvesting. The single incision technique is a typical technique for harvesting connective tissue from the palate. (a, b) Measurement with a probe, the initial incision is drawn approximately 2.0 mm apical to the gingival margin. (c) The incision line is drawn perpendicular to the palatal mucosa to the depth of 1–1.5 mm. (d) The incision might extend mesial to the first premolar and distal to the first molar in general, be cautious about the branches of the greater palatine artery. Then the scalpel is oriented parallel to the surface of the palatal tissue. (e) While visually recognizing the scalpel blade that is transparent from above the epithelium, a partial thickness incision is made to uniform depth at a depth of 0.5–1 mm from the epithelium. (f) The depth of the partial thickness incision should be calculated in respect to the length of the scalpel blade to reduce the risk injuring the artery



**Fig. 4** Continuing from Fig. 3 for single incision to harvest palatal tissue. (a) Proceed with the periosteal incision at a deeper position parallel to the surface of the palatal mucosa while still leaving the periosteum on the bone. (b, c) Carefully separate the required amount of connective tissue to be harvested. (d, e, f) With compression hemostasis, a single incision is closed with a simple continuous suture using a 6-0 or 7-0 suture

**Table 2** Advantages and disadvantages of the abovementioned techniques for harvesting soft tissues from the palate

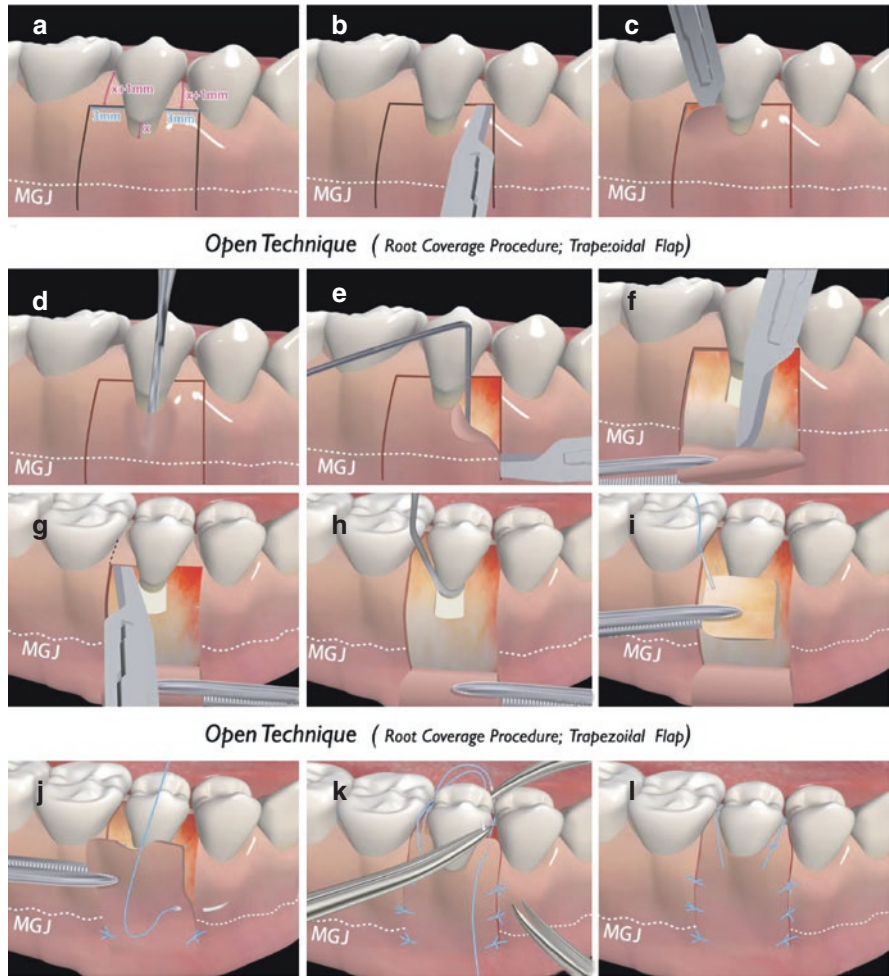
Tissue harvesting methods	Advantages	Disadvantages
Trapdoor	Full access to the underlying CTG	Compromise healing due to vertical incisions Possible uneven graft thickness
Double incision	Include the epithelial layer	Limited access Possible uneven graft thickness
Single incision	Minimally invasive	Limited access Possible uneven graft thickness
De-epithelialization of FGG	Fast Better control of the graft thickness	2nd intension healing Extra step of de-epithelialization extra-orally Harder for bleeding control

**Table 3** Two major techniques used based on recipient-site considerations

Open Technique (Trapezoidal flap, Triangular flap, etc.)	Closed Technique (Envelope Flap, tunneling flap, etc.)
Easier to perform	More difficult to prepare (blind technique)
Allows for direct visualization of dissection for uniform recipient site preparation	Immobilization of graft is more technique sensitive
Facilitates coronal advancement (>4mm)	Limits coronal advancement ( $\leq 4$ mm) Limited indication when the vestibular depth is minimal
Use of releasing incisions sacrifices circulation	Preserves circulation to area
May require secondary gingivoplasty	Allows for superior esthetics

incision with or without a vertical incision is called an open flap technique. The open flap technique is termed when the flap is advanced using intrasulcular/submarginal incisions to form a coronally advanced flap (CAF) (Fig. 5). This method is easier for access to the periosteum on the recipient bed, and for security of the tissue transplant. The modern treatment of root coverage procedure is based on the CAF named by Pini Prato [12] in 1999. Many modified techniques have been proposed with CAF alone or in combination with other procedures. There are methods in which CAF is used alone, in combination with some treatment (mainly transplantation), and in combination with biologics (Fig. 1). Examples of the open approach are the original Langer method [9], modified Langer method [13], and sling and tag method [14]. This technique is indicated when the flap needs to be extended greatly toward coronally, such as in cases where the exposed root surface or the implant abutment needs to be covered. When combining a CTG, it is beneficial that the flap covers the graft for ensuring adequate blood supply, and minimal compression to the underlying graft. However, the vertical incision is surgically invasive, blocks blood flow, and

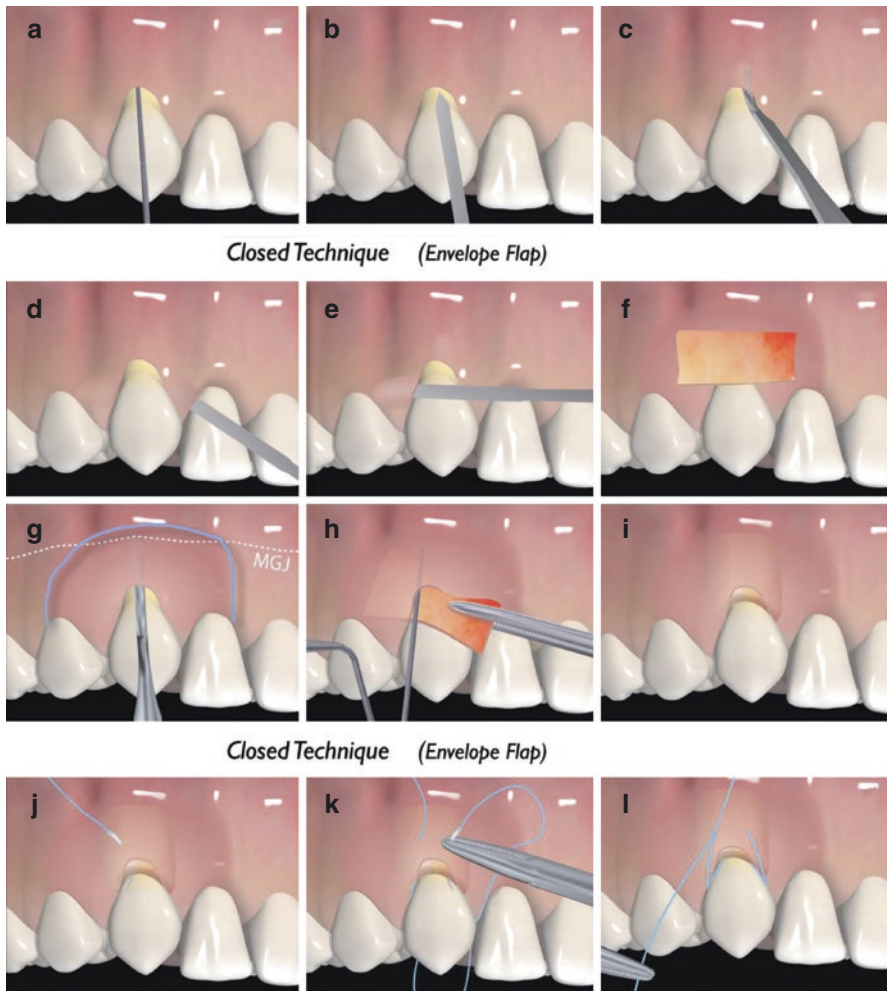




**Fig. 5** Open technique for soft tissue augmentation. (a) The horizontal incision is located at  $(x + 1)$  mm to the papilla tip; whereas  $x$  = the midfacial recession amount). (b, c) Full-thickness incision is made at the horizontal and vertical incisions. (d) Intrasulcular incision is made. (e, f) Full-thickness flap reflection and flap releasing beyond MGJ. (g) De-epithelialization of the papillae. (h) Mechanical root surface treatment when indicated. (i) Security of the CTG to the recipient bed. (j-l) Suturing of the flap with interrupted and slight sutures

takes longer time to heal. Furthermore, there is a risk of scarring after surgery, and there are drawbacks such as the need for secondary gingival surgery.

Alternatively, the closed technique without vertical releasing incisions can be applied (Fig. 6). Azzi et al. introduced a technique that has the advantage of covering the graft, referred to the so-called movable cover flap without incision lines as a “pouch & tunnel technique.” It can be applied in root coverage, with stable graft underneath the flap [15–18]. Examples of the closed approach include the envelop

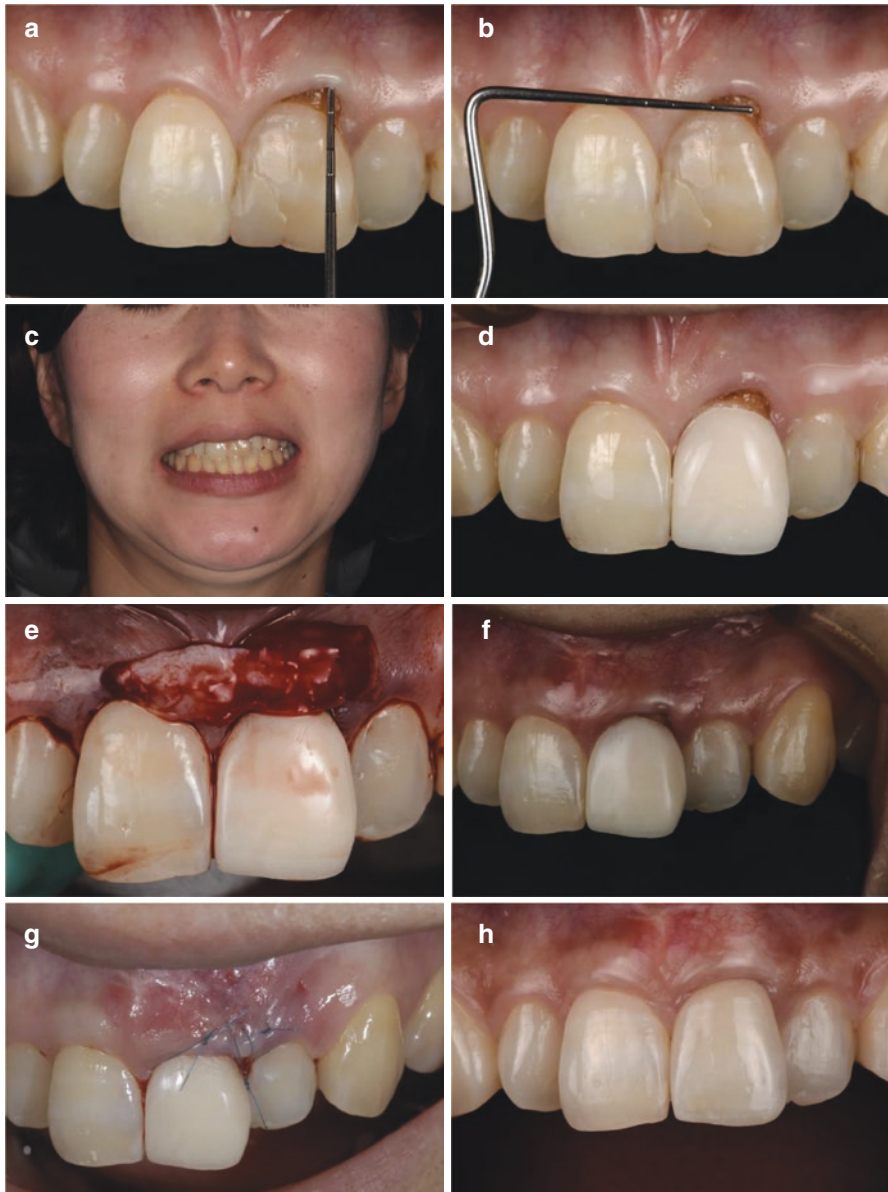


**Fig. 6** Closed/envelope technique for soft tissue augmentation. (a) Measurement of the defect with a probe. (b) Intrасulcular incision with a microblade. (c) Flap releasing in a closed approach. (d, e) Papilla releasing. (f) CTG/tissue substitute harvest and placement. (g) The flap releasing extends to adjacent tooth and apical to MGJ. (h, i) Placement of the graft. (j–l) A sling suture is placed for securing the graft and flap

technique and tunneling technique. The closed technique that avoids a vertical incision facilitates blood flow to the surgical site and is likely to have more esthetic results [11]. Also called a “blind technique,” it is generally considered more difficult to perform, but is less invasive with a shorter healing time. However, contrary to the open technique, it is difficult to reliably dissect the muscular tissue, and the amount of coronal advancement can be less.

Since the closed approach is technique sensitive and requires delicate handling, microsurgery has a distinct advantage. When approaching the gingival margin or





**Fig. 7 (a–j)** A case (case 1) treated with a closed technique and CTG for improving prosthetic outcomes. Please see the text for details

interdental papilla, great care can be taken to avoid damaging the tissue by higher magnification and illumination provided by the OM.

Case 1 presented an example of soft tissue augmentation before prosthetic reconstruction (Fig. 7a–k). The patient is a 40-year-old woman. She came to the clinic



**Fig. 7** (continued)

with an esthetic problem of the maxillary left central incisor (Tooth #9) (Fig. 7a–c). She had a trauma at that region and the incisal edge was fractured and restored with composite resin. At that time, pulpectomy was also performed. Gingival recession of 2 mm was also observed on #9 (Fig. 7a). The exposed root surface was rough and recession width was wide. (Fig. 7b). The patient was not interested in orthodontic treatment. Therefore, a root coverage procedure was proposed. A provisional crown was placed (Fig. 7d). A tunneling technique with connective tissue harvested from the palate was performed to correct the recession on teeth #8 and #9 (Fig. 7e). Two months after the surgery, some improvement was seen, but not sufficient (Fig. 7f). A revision surgery was performed (Fig. 7g).

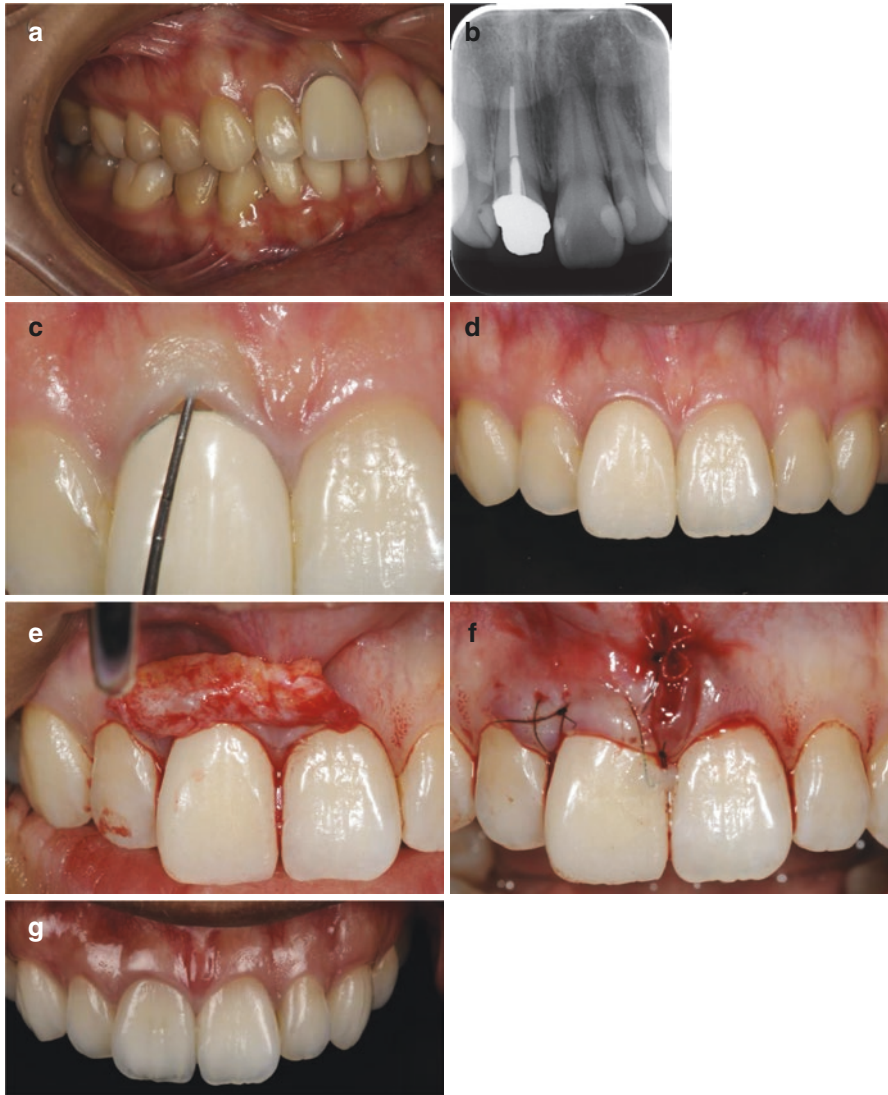
The provisional restoration was replaced with a final prosthesis on tooth #9 (Fig. 7h, i). Two years after installing the final prosthesis, tissue health and harmony were achieved (Fig. 7j).

#### 4 Preprosthetic Gingival Augmentation

Gingival recession causes esthetic and functional problems not only in natural teeth and prosthetic restoration procedures but also in implant restoration. Restoring this is one of the most difficult procedures in PPS. Valderhaug [19] in a long-term clinical trial showed gingival recession was 40% 1 year after restoration and 70% 10 years after restoration of 300 crown restorations with subgingival margins. Furthermore, Tao et al. [20] compared gingival phenotypes, and because of 5 years of follow-up with 100 metal ceramic single crowns showed gingival recession was more pronounced in thin biotypes, with  $1.09 \pm 0.22$  mm and  $0.31 \pm 0.16$  mm for thin and thick biotype, respectively. Seven crowns with thin biotype were evaluated as unsuccessful due to esthetic problems. These results indicate that the frequency of gingival recession after prosthetic restoration is unfortunately common, especially in thin gingival phenotypes. Zuhr et al. [18] found that gingival overgrowth is an effective procedure for soft tissue stability and prevention of recession when the prosthesis margin needs to be set below the margin in patients with thin biotypes. Therefore, it is indicated to prophylactically thicken the gingiva for successful treatment outcomes in selected cases, especially when there is a risk of postoperative

gingival recession. The timing of transition to provisional restoration is based on the time when epithelial attachment and connective tissue attachment, which are the concepts of biological width, are reconstructed and matured, as in the case of the next surgical crown lengthening. Therefore, it is necessary to observe the stability of the gingiva by long-term provisional restoration for this gingival overgrowth.

Case 2 (Fig. 8): This patient is a 21-year-old, college student. She visited the clinic with the chief complaint of esthetic problem of the maxillary right central



**Fig. 8** A case (case 2) presenting CTG to improve gingival thickness and esthetics before restoration

incisor restored with a crown, with gingival discoloration (Fig. 8a). The X-ray showed satisfactory root canal treatment (Fig. 8b). In the close-up view, coloring of the crown margin was observed, and the attachment of the upper lip frenum was high (Fig. 8c). When tooth #8 was replaced with a provisional crown, the discoloration improved, but the crown was slightly longer than tooth #9 due to slight recession (Fig. 8d).

Connective tissue was harvested from the palate by the single incision technique. Then, after trying it on the recipient site, trimming and adjustment were performed under magnification. The graft was then fixed to the recipient bed performed by tunneling flap (Fig. 8e). The frenum was removed at the same time, and two interrupted sling sutures were performed (Fig. 8f). Eight months after the final prosthesis was placed, a satisfactory esthetic outcome was achieved (Fig. 8g).

Case 3 (Fig. 9): This patient visited the clinic complaining of esthetic problems of the mandibular anterior teeth after the completion of surgical orthodontic treatment (Fig. 9a). There is evidence of severe clinical attachment loss in this problematic region, confirmed by horizontal bone defect extending to 1/2 of the roots (Fig. 9b). The plan was to improve the thickness of the gingiva, after which single crowns were placed. Partial thickness flap was performed with scalloped incisions in the papillae and a connective tissue graft was placed in the right side (Fig. 9c). Healing at 3 months after the surgery showed thickening of the gingiva (Fig. 9d). Three months after the surgery on the right side, the same procedure was performed on the left side (Fig. 9e, f). Two years after the surgery, provisional restorations were placed (Fig. 9g, h). The gingiva was in harmony with the restorations. When the final prostheses were placed, long interproximal contacts were able to close the open space between the teeth with esthetically appealing gingiva (Fig. 9i).

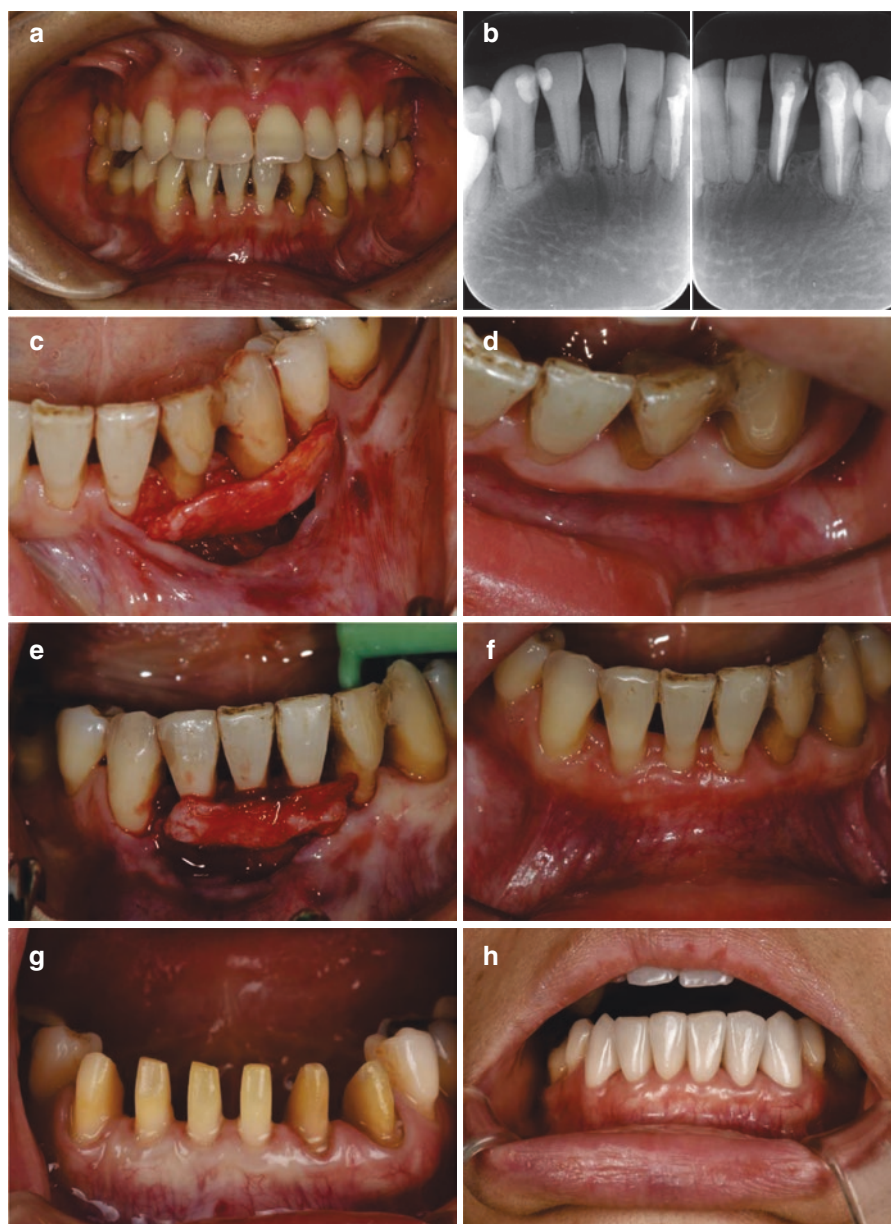
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## 5 Surgical Crown Lengthening

Crown lengthening is a surgical procedure used to build a prosthetic and esthetically pleasing gingival morphology. Subsequent prosthetic restorations are as important as the surgery itself, such as setting margins, adjusting provisional restoration subgingival contours, and timing of final restoration. Cases in which extension of crown length is required can be broadly divided into prosthetic/functional requirements and esthetic requirements.

Prosthetic requirements are indicated when (1) there is not enough tooth structure for restoration, e.g., subgingival caries or fracture, and (2) realigning the occlusal plane disturbed by tooth extrusion is needed. On the other hand, as an esthetic requirement, the teeth appear short, and the gingiva is overexposed while smiling, so-called gummy smile. The etiology of “gummy smile” is multifactorial (Table 4); therefore, prudent examination and correct diagnosis are important. “Altered passive eruption” is common and can be addressed with crown lengthening. It is estimated to occur in approximately 10% of the population. During normal passive eruption, the gingiva-alveolar complex moves apically to establish supracrestal attachment tissue (SAT). When this normal process does not occur, it is called





**Fig. 9** Example of preprosthetic soft tissue augmentation in the mandibular anterior region





**Fig. 9** (continued)

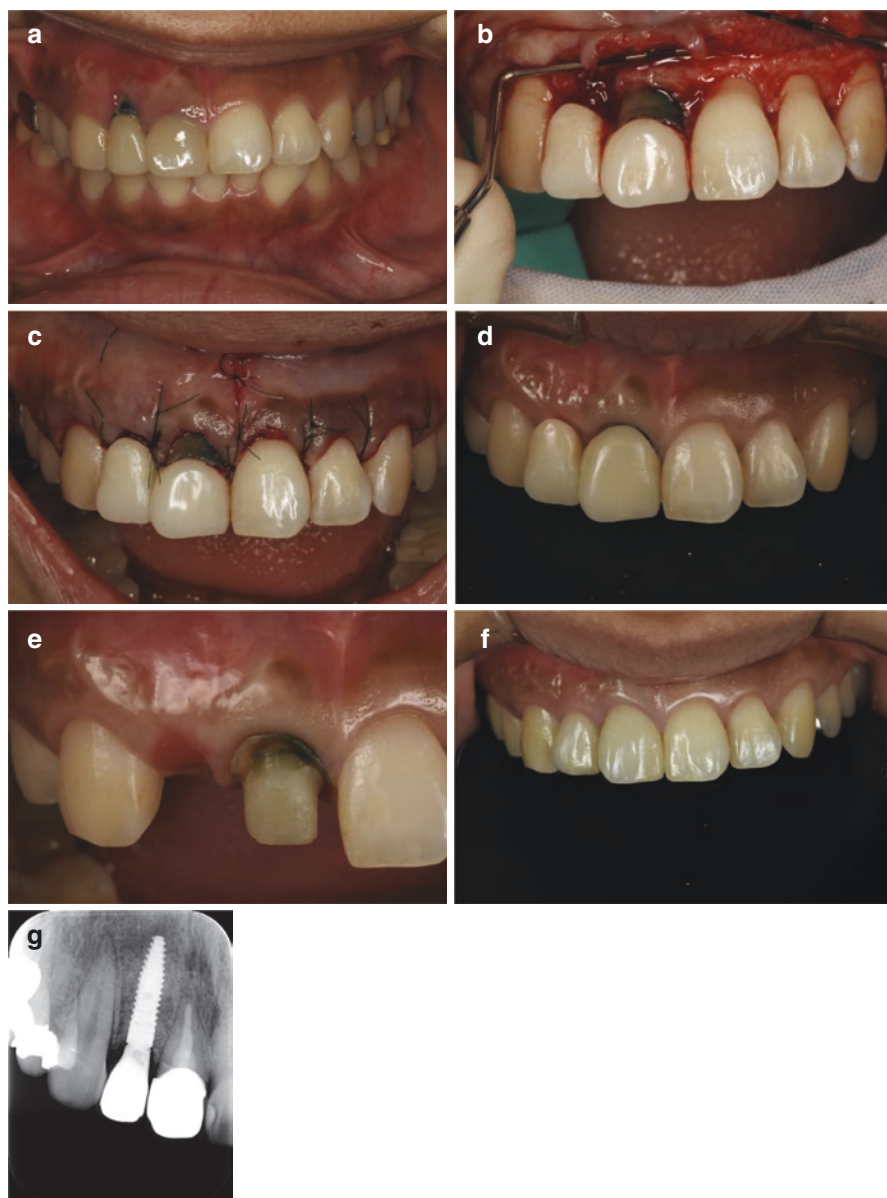
**Table 4** The main etiologic factors of excessive gingiva display and possible solutions

Etiology	Solutions
Skeletal (long lower face)	Orthognathic surgery
Muscular (hypermobile lip)	Lip repositioning surgery; Botox application
Dental (tooth attrition)	Crown lengthening followed by restorations
Altered passive eruption	Crown lengthening with/without restoration

altered passive eruption [21, 22]. Altered passive eruption is classified into four types according to the width of the keratinized gingiva and the positional relationship between the alveolar crest and CEJ [23].

Case 4 (Fig. 10): A healthy 34-year-old female patient and a non-smoker presented at our clinic with complaints of pain in tooth #7 and gingival swelling. The labial gingiva receded with pus discharge from the periodontal pocket, and a vertical root fracture was suspected (Fig. 10a). Uneven gingival margins were observed, due to altered passive eruption in the maxillary anterior region. A decision was made to replace tooth #7 with a dental implant and crown lengthening of the area (Fig. 10b, c). Three months after #7 extraction and socket augmentation and the crown lengthening, an implant was placed under OM. Four months after implant placement, the second surgery was simply applied with a minor roll technique. Temporary restoration (Fig. 10d, e), final restoration (Fig. 10f), and the radiograph showed satisfactory outcomes (Fig. 10g).

Case 5 (Fig. 11): A healthy 40-year-old female came to the clinic with a complaint of unesthetic appearance in her maxillary anterior teeth. Resin facing cast crowns were placed on teeth #8 and #9 (Fig. 11a). The gingival line of anterior teeth



**Fig. 10** A combination of crown lengthening and implant therapy for restoring anterior esthetics. See Case 4 for details



**Fig. 11** Soft tissue augmentation to improve the thickness and contour around maxillary anterior teeth. Please see Case 5 for details

was uneven with slight crowding. The patient was not interested in orthodontic treatment. It was then decided to improve the esthetics as much as possible by prosthetic restorations. As a preprosthetic treatment, CTG was planned to be placed on #8 and #9, along with #10 crown lengthening. All planned prostheses were replaced with provisional restorations before the scheduled surgery (Fig. 11b). An intrasulcular incision was placed with a microblade and tunneling in the closed technique. Only distal papilla of #10 was elevated to ensure access to the alveolar crest for crown lengthening. Ostectomy of the bone was performed using round diamond burs. At this time as well, care must be taken not to damage the roots as much as possible under microscope. This is a procedure that can only be performed precisely under enlargement. Periodontal fibers remaining on the root surface must be removed carefully with ultrasonic devices. Collection of CTG was performed using

the single incision technique. The CTG was placed on the labial side and the grafts are fixed with 6-0 sling sutures (Fig. 11c, d). The contour and the gingival margin improved compared to before surgery. Eight months after the surgery, the final prosthetic restorations were placed. At 1 year, the patient was very pleased with the results (Fig. 11e–g).

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## 6 Papilla Reconstruction

A short papilla that does not fill the interdental space can be an esthetic concern. Factors to be considered include the space size and morphology, tooth positioning, periodontal phenotype, and the level of the alveolar crest. It might be improved by prosthetic treatment and/or orthodontic treatment. When it comes to surgical reconstruction, many different surgical procedures have been reported using autologous tissue, and various results have been shown [15, 24–29]. However, most of these studies are case series with a short-term outcome, and the reconstruction of the lost interdental papilla cannot be predictable. The primary challenges are due to limited blood supply and inability of the tissue transplant to keep the volume in this constrained space. Zuhr et al. [18] suggest that the grafts used for papilla reconstruction should be harvested from the maxillary tuberosity, which is rich in collagen fibers.

Case 6 (Fig. 12): The patient is a 50-year-old woman with a complaint of an esthetic issue in the maxillary anterior teeth. In particular, she was dissatisfied with the coloring of teeth #7 and #8 and the black triangle between the teeth (Fig. 12a). On X-ray, the crestal bone between #7 and #8 was higher, and the interdental distance was considered wide (Fig. 12b). Both the teeth were restored with composite resin. Gingival recession was also observed in both the teeth (Fig. 12c). Under local anesthesia, the root surface was flattened to promote reattachment before the scheduled root coverage and papilla reconstruction surgery (Fig. 12d). The tunneling procedure was performed, followed by placement of the two CTGs harvested from the palate on the labial side and under the papilla (Fig. 12e). Enamel Matrix Derivative (EMD) was also applied on the root surface after 24% of EDTA for 2 min to enhance the effect of reattachment to the root surface. The flap was repositioned coronally with interrupted sling sutures (Fig. 12f). Two months after the surgery, the restorative phase was initiated (Fig. 12g). At this point, the margin of the provisional restoration was determined. Four years after the surgery, the esthetic result was maintained, even though there was slight gingival redness on tooth #7 (Fig. 12h). The radiograph showed stable bone crestal level and re-established interdental contacts between teeth #7 and #8.



**Fig. 12** Pre-prosthetic surgical papilla reconstruction for improve esthetics. Please see Case 6 for details



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## 7 Conclusion

The appearance of restorations has become so vivid and natural tooth-like thanks to the evolution of materials and technology sciences. It is also the result of the great laboratory work from dental technicians. To further improve the esthetic outcome, healthy and esthetically pleasing periodontal tissues should be established. The field of periodontal plastic surgery is evolving in this aspect. In recent years, microscope-assisted periodontal plastic surgery has achieved improved clinical outcomes by allowing minimally invasive, precise, and delicate touch to periodontal hard and soft tissues. This chapter serves as a testimony to this and to encourage fellow dentists to join us for this exciting journey.

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## 8 Key Points

1. Preprosthetic surgical procedures can improve the esthetic and functional outcomes. These procedures deal with the transition zone, requiring precise and gentle handling of soft and hard tissues. Therefore, applying operating microscope would be beneficial for these delicate procedures.
2. Commonly applied preprosthetic surgical procedures include (1) free gingival graft/connective tissue graft for increasing zone of keratinized mucosa, (2) root coverage with closed or open technique, (3) functional or esthetic crown lengthening, and (4) papilla reconstructive procedures.
3. A free gingival graft/connective tissue graft can be collected from the maxillary tuberosity or the palate. Harvesting from the palate is the most common because of the availability. Tuberosity tissue may contain higher collagen, providing volume stability but at the same time harder to become vascularized.
4. The closed technique for root coverage can be effectively performed under microscope, which is considered less traumatic, compared to the open technique, and can promote better wound stability.
5. Etiologies of excessive gingival display may include skeletal discrepancy, hypermobile lip, altered passive eruption, and tooth attrition. Altered passive eruption can be effectively treated with a crown lengthening procedure.
6. Papilla reconstruction is still challenging and unpredictable; however, with a combination of restorations and surgical papilla reconstruction the esthetic outcome may be improved.

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