

Simplified Tunneling Procedure for Root Coverage using Acellular Dermal Matrix (Alloderm)

Factors Associated with Clinical Success

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Background Information

Gingival recession is a pathologic migration of the gingival margin with exposure of the root surface to the oral cavity.¹ It is found in population with good oral hygiene^{2,3} and it is most commonly located on the buccal surfaces.⁴ It occurs frequently in adults and has a tendency to increase with age. Recent survey by Kassab et al⁶ revealed that 50% of the population between the ages 18 and 64 have one or more sites with gingival recession, while 88% of the patients older than 65 have at least one recession and the number recession defects increases with age.⁷

There are many classifications of the gingival recessions. (Sullivan and Atkins, Miller, Smith, Cairo.) However, all these classifications have some limitations in the diagnosis of gingival recession and the associated root condition. The newly proposed classification by Cortellini and Bissada⁸ tries to overcome the deficiencies associated with the previous classifications. This classification includes not only the classification of the gingival recession, but also the classification of the gingival biotype. According to the authors is a treatment oriented classification based on the interdental CL (Cairo score, RT) and complemented with the qualifiers of recession depth,

gingival thickness keratinized tissue width and also the root surface condition such as the presence/absence of the NCCL and the presence absence of the CEJ. Furthermore it also includes aesthetic concern of the patient and the presence of dentin hypersensitivity. There are many clinical implications of recession: esthetics concerns to the patients, dentin hypersensitivity, non-carious cervical lesions such as abrasion and erosion and also root caries. Various root coverage procedures with different degrees of success have been recommended in the past for the treatment of gingival recession. These procedures include but are not limited to coronally positioned flap⁹ double papilla flap¹⁰, semilunar coronally positioned flap¹¹, subepithelial connective tissue graft¹² etc. Among these techniques the subepithelial CT based procedures provides the best outcomes in terms of root coverage and increase in the KT¹³. According to the same authors subepithelial connective tissue (CT) - based procedures and coronally advanced flap plus acellular dermal matrix grafts, enamel matrix derivative, or collagen matrix led to the best improvements of recession depth, clinical attachment level (CAL) gain, and keratinized tissue (KT). However, the CTG has some disadvantages. There is a limit in the amount of the graft that can be harvested



Fig.1a and Fig 1b: Miller class I gingival recession (pre and post operative results)

and it requires a secondary surgical site, increasing the morbidity of the procedures. For patients with generalized recession additional site may be required or the patient may be subject to multiple surgeries to acquire sufficient graft required.

To overcome these disadvantages ADM has been used for gingival augmentation procedures. AlloDerm (LifeCell), widely used in both medical and dental surgery over the past 10 years, is an acellular dermal matrix. It is derived from donated human skin tissue supplied by tissue banks in the United States utilizing American Association of Tissue Banks standards and FDA guidelines. AlloDerm provides a viable biologic substitute for palatal donor tissue. Compared to the CTG ADM offers several advantages; no donor site, unlimited supply, similar clinical outcomes in the treatment of multiple recessions. In a recent systematic review Chambrone et al ¹⁴ recommended that Alloderm and Coronally advanced flap may be used as an alternative to autogenous connective tissue graft. Gaspky et al ¹⁵ reported that there is no statistically differences between the ADM and CTG in recession coverage, gain of KT and probing depth reduction. AlloDerm (LifeCell), widely used in both medical and dental surgery over the past 10 years, is an acellular dermal matrix. It is derived from donated human skin tissue supplied by tissue banks in the United States utilizing American Association of Tissue Banks standards and FDA guidelines. Alloderm (ADM) is an allograft, chemically processed to remove all epidermal and dermal cells but preserve the remaining bioactive dermal matrix. AlloDerm provides a viable biologic substitute for palatal donor tissue. ADM works like an autogenous graft by providing a bioactive matrix consisting of collagen, elastin, blood vessel channels and bioactive proteins that support the revascularization, cell repopulation and tissue remodeling. Alloderm is considered a safe alternative to the autogenous grafts. In over 10 years of use and over 900,000 graft completed the were zero cases of viral transmission ¹⁶. Compared to the CTG, ADM offers several advantages; no donor site, unlimited supply, similar clinical outcomes in the treatment of multiple recession.

Mucogingival therapy is described, by definition, the procedures that are undertaken to correct defects in the morphology, position and/or amount of the soft tissue around teeth and dental implants ¹⁷. Given that most of these procedures are performed to correct esthetic problems, there is a lot of debate in the scientific community about which are the best and also the least invasive surgical techniques to cover gingival recession with a predictable and long term esthetic outcome. Irrespective of the technique chosen, the esthetic outcome of the mucogingival procedure depends on a series of factors that affects not only the wound healing but also the integration of the grafts either autogenous or allografts. The successful integration of these various grafts depend upon a series of clinical factors (blood supply to the surgical site) , but also on technique related factors (surgical procedure and wound stability) and also on patient related factors (OH compliance , prevention of bacterial infection post surgery). The purpose of this article is to identify the essential elements for performing the modified tunnel technique with acellular dermal matrix (ADM) in the esthetic zone in patients with long term successful outcome.

10 Keys for successful grafting

The 10 keys are as follows:

1. Patient related factors
2. Site related factors
3. Surgical instruments
4. Surgical procedure (micro tunnel technique)
5. Papilla preservation technique
6. Root preparation
7. Graft size
8. Wound stabilization
9. Retraction resistance
10. Postoperative care



Fig.2a and Fig 2b: Miller class II pre and post operative .

Key #1. Patient selection and diagnosis of gingival recession

Achieving a long term esthetic result starts with a comprehensive planning prior to the surgical intervention. A patient pretreatment evaluation for soft tissue grafting in the esthetic zone should start with an initial evaluation to establish a diagnosis and prognosis based on a comprehensive examination of the medical , dental and compliance history . The patient related prognostic factors should be carefully evaluated before the surgery . Systemic health factors, smoking habits , oral hygiene, traumatic tooth brushing /flossing techniques , are essentially controlled by proper evaluation of the individual case . It is essential that all the periodontal treatment should be completed before the surgery. Absence of marginal tissue inflammation , probing depths within normal limits, absence of BOP and exudate should be evaluated before the surgical appointment . Furthermore , patient compliance to OH instructions will be a good indicator if the patient will follow the post surgery instructions or not.

Key #2. Site related factors

Site related factors (recession classification , papilla dimension , vestibular depth, tissue thickness, amount of KG , extent /anatomy of the defect)

a) Recession classification

Defect evaluation and recession classification plays a key role in the success of achieving complete root coverage by using the modified tunnel technique and the addition of the ADM. One of the most common and widely used gingival recession classifications was proposed by Miller et al¹⁸. According to the authors, gingival recession can be classified in four classes depending on the extent of gingival recession and on the level of interproximal bone. In Miller Class I gingival recession, the recession does not extend to the mucogingival junction of the adjacent teeth, there is no loss of the interproximal bone, and the papillae completely fills the interdental space. These cases can be successfully treated with the tunnel technique, 100% of root coverage can be expected in these cases.

In Miller class II defects the gingival recession extends to the Mucogingival junction of the adjacent teeth . There is no loss of the interproximal bone, and the papillae also completely fills the interdental space. In these cases 100% of root coverage can be expected.

In Miller class III recession defects the gingival recession extends to or beyond the MGJ of the adjacent teeth , there is loss of the interdental bone, teeth might be malpositioned. In these cases complete root coverage can be expected in 75% of the cases.

In Miller class IV gingival recession defects the gingival recession extends to or beyond the MGJ of the adjacent teeth, there is loss of the interdental bone or soft tissue (apical to the extent of gingival recession , teeth can be severely malpositioned . In these cases root coverage is not anticipated.

b) Tissue biotype

A recent systematic review classified the periodontal biotypes in three categories¹⁹. Thin scalloped biotype - associated with slender crowns , interproximal contacts close to the incisal edge, clear thin delicate gingiva, and a relative thin alveolar bone . Thick flat biotype associated with square shaped tooth crowns, large interproximal contact located more apically , broad band of KG , thick fibrotic gingiva, and a comparatively thick alveolar bone. Thick scalloped biotype showing thick fibrotic gingiva, slender teeth , narrow zone of KG and a pronounced gingival scalloping. The easiest and the most convenient method to asses the gingival thickness is by placing the periodontal probe into the sulcus. According to Kan et al²⁰ gingiva is classified as thick (>1mm) or thin (<1mm) upon the observation for the periodontal probe visible through the gingiva. Tissue thickness is an important factor in achieving predictable root coverage . According to Baldi et al²¹ a minimum of 0.8 mm flap thickness in coronally advanced flap procedure for the treatment of single Miller Class I and Miller Class II recession defects is associated with better clinical outcomes with regards complete root coverage. The authors suggested that thicker flaps are associated with a more stable vascular network, which is

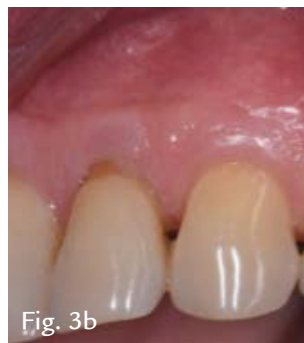


Fig.3a and Fig 3b: Miller class III



Fig 4. Miller class 4 gingival recession

important for the graft and the flap survival. Furthermore a thicker tissue / flap responds in more predictable way the surgical insult than a very thin (< 0.8 mm)

Key #3. Surgical instrumentation

The correct use of specifically designed surgical instruments are critical for performing the surgical procedure. The introduction of the micro surgical blades and of the surgical loops and / or surgical microscope play a key role in the success of the surgery . Preparation of the interdental papilla in full-thickness flap elevation requires specifically designed micro surgical instruments to prevent the tearing of this fragile tissue which is one of the critical aspects of the micro tunnel surgical technique. The deep tissue dissection of the buccal flap, in a split thickness procedure, to increase its mobility and facilitate the coronal advancement also requires special attention. To facilitate this part of the surgical procedures specially designed surgical tunnel instruments are used to minimize the soft tissue trauma and decrease the risk of perforation. Several clinical studies ²² also confirmed that the use of micro instruments and magnification accounted for less tissue damage and therefore superior outcomes compared to the routinely used periodontal surgery instruments in routine condition. Minimally invasive surgical protocols with sharp instruments that provide sharp cuts instead of laceration and contusions combined with delicate tissue manipulation is the recommended protocol to perform periodontal surgeries.

Key #4a. Surgical procedure

Various surgical techniques have been investigated with the aim of achieving not only root coverage but also a naturally looking surgical site , similar to the adjacent soft tissue of the adjacent teeth .To avoid vertical releasing incisions Raetzke ²³ reported the envelope technique, in which the CTG is placed in an envelope created around the denuded root surface by an undermining split-thickness preparation The envelope technique was originally proposed for single teeth, Allen ^{24, 25} demonstrated the use of a suprapariosteal envelope technique on multiple



Fig 5. Modified minimally invasive tunnel procedure

adjacent areas of recession. Mahn et al ^{26, 27} proposed a tunneling technique to accommodate the use of ADM in the treatment of multiple adjacent recession defects.

Azzi and coworkers ²⁸ demonstrated a modification of this technique in 2002 when they created a mucoperiosteal-mucosal tunnel through sulcular incisions, including the papillary tissues. Zuhr et al²⁹ modified the tunnel technique using micro surgery instruments.

The tunneling approach provides better blood supply, quicker healing , less scarring and less operative discomfort than the classical coronally advanced flap with vertical releasing incisions. Furthermore according to Mousa et al ³¹ the tunnel technique is far superior with respect to esthetic outcome than the coronally advanced flap. Scar formation, misalignment of MGJ, and papillae loss all contributed to an inferior score obtained with the CAF. In a different study Zuchelly et al ³² concluded that the groups treated with CAF without vertical releasing incisions lead to greater predictability in root coverage, better esthetics (less formation of the keloid bodies), better postoperative course, and shorter surgical appointments. It seems obvious that avoiding any kind of vertical releasing incisions will allow for better esthetic outcome because it minimizes the risk of postoperative scar formation. For this reason the tunnel flap procedure has developed into an essential clinical tool in mucogingival surgery in the esthetic zone. The major disadvantage of this surgical technique is the time required to complete the procedure and the experience of the operator.

Key #4b. Surgical protocol for tunnel technique

Besides the patient selection and proper diagnoses of the gingival recession the surgical technique related factors have a major impact on the predictability and long term overall outcome of the mucogingival surgery. The handling



Fig 6. Conventional CAF with vertical releasing incisions

	Envelope technique (Raetzke) Zabalegui³⁰ Connected multiple envelope laps	Original Tunnel technique / modified tunnel technique Allen	Modified tunnel technique Azzi et al	Modified tunnel; technique Mahn et al	Modified tunnel technique Microsurgery Zuhr et al	Boeriu proposed Surgical technique
Indications	Singular recession defects	Multiple recession defects	Single or multiple adjacent recessions	Multiple adjacent recessions	Multiple recession	Single or multiple adjacent recession defects
Horizontal extension of the mucosal flap	One tooth	Multiple adjacent teeth	Multiple adjacent teeth	Multiple adjacent only teeth with recession		Flap extended to the line angles of the adjacent teeth without recession
Flap design	Split thickness Buccal area only	Full thickness continued with split thickness Buccal area only	Buccal area	Full thickness Buccal area only	Split thickness Buccal area only	Full thickness to MGJ on the Buccal interproximal split thickness in the alveolar mucosa on the buccal surface (8-10 mm)
Mobilization of the adjacent papillae	No	No	Yes	No	Yes	Yes
Coronal advancement of the flap	No CTG was left exposed	No /later yes	Yes	Yes	Yes	Yes
Tissue	Connective tissue graft is left exposed	Alloderm , 1 mm exposed or completely covered	CTG	Alloderm / CTG	CTG, can be left partially uncovered	Alloderm Completely covered by the flap
Suturing technique	Single interrupted	Continuous sling	Horizontal mattress sutures	Alldoerm secured first with continuous sutures Advance the flap with continuous sling sutures	Vertical mattress	Double sling around each tooth technique capturing the alloderm and the flap together
Vertical incisions	No	No	No	Yes	No	No

of the soft tissue is the most crucial aspect of the periodontal and implant surgery since it directly influences the preservation of the blood supply and the course of the wound healing. The exact procedure from the flap design, initial incision outline, flap elevation and advancement and also the flap closure of the wound should be planned before the surgery.

Recommended Step by step surgical protocol for the minimally invasive tunnel technique

a) Flap preparation starts with sulcular incisions around the neck of each tooth within the sulcus, buccal interproximal, lingual (palatal) to sever the attachment for the base of the sulcus to the osseous crest. The use of a microsurgical blade with a rounded tip and sharp edges on either side is the instrument of since it provides easy access to the bone crest (through it's design) but also it minimizes the risk of cutting the gingival margin (Figure 7).The purpose of the intrasulcular incision is to include the full thickness of the marginal tissue into the flap , but also to prevent the re-attachment of the supracrestal fibers to the root surface.



Figure 7

b) Blunt dissection, using a full thickness flap technique is continued to the MGJ using a periosteal elevator. The blunt dissection is extended beyond the MGJ and undercuts in order to reduce the risk of perforation and to preserve the thickness of the flap which is one of the critical determining factors in achieving root coverage.

c) Sharp dissection of the alveolar mucosa from the periosteum is performed in a split thickness flap deep into the mucosal tissue using a Modified Orban knife. The split thickness flap is extended into the alveolar mucosa of the vestibule at least 10 mm beyond the MGJ. The surgical microblade of the Modified Orban knife should be positioned in such a way that the flat surface should be kept in permanent contact with the underlying bone. This will ensure the correct surgical cut, leaving the periosteum attached to the bone creating a pedicle flap. The split thickness flap created will facilitate the mobility of the pedicle flap and its coronal advancement of the flap. By leaving the periosteum attached to the bone, it will provide a rigid bed for the graft fixation.

Key #5. Papillae preservation

Papilla preservation is not only one of the key elements in the flap design but also one of the factors that affect the outcome of the surgical procedure. Preserving the interdental papilla is critical for the micro tunnel periodontal surgery. Experience associated with literature reviews shows that once the papillae is cut it is very hard to achieve healing by primary intention due to a multitude of factors such as : the interdental tissue is very limited in amount which limits the possibility of stabilisation of the flap and suturing, during the healing period the interdental areas the mechanical and microbiological challenge is the highest in the interproximal areas and the risk of secondary healing in the interproximal areas is very high. The papillae preservation will also aid in the maintenance of the blood supply to the surgical area since most of the blood supply of the interdental papilla comes from the palatal site not the buccal flap. Furthermore by keeping the papillae intact, this will aid in the stabilisation of the surgical site, by preventing the pull of the tissues during the initial stages of the healing.

The intrasulcular incision is performed around the neck of each tooth around the circumference (buccal, mesial, distal and palatal). By extending the intrasulcular incision palatally the risk of tearing up the papilla during its elevation is reduced. After the intrasulcular incision is completed the papillae is elevated from the interproximal bone with a Younger Good curette. This will advance the flap coronally by detaching the papillae from the alveolar crest.

Key #6. Root preparation

Root preparation was accomplished by the means of Younger Good curette and or Neumeier burs to bevel the sharp edges and



Figure 8



Figure 9

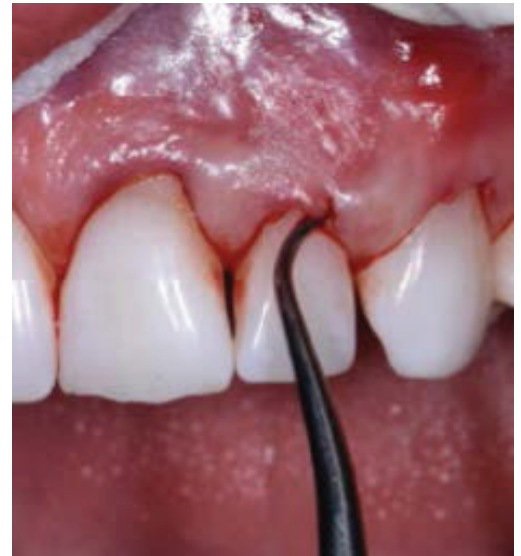


Figure 10

obtain a concave uniform surface, to remove the shallow restoration and expose the underlying dentin. The exposed roots were prepared by applying 17 % EDTA (ethylenediaminetetraacetic acid) for 1 minute with a cotton tip applicator. The EDTA will aid in the removal of the smear layer and the opening of the dentinal tubules, exposing the collagen fibers, and encouraging the migration of fibroblasts on the root surface.

Key #7. Graft Size

a) Alloderm hydration

The alloderm should be hydrated in saline solution. It has been determined that the alloderm will perform optimally if the hydration is 10 minutes or more prior to use. After the alloderm has been hydrated for at least 10 minutes in saline it should be transferred to a second dish containing normal saline with 250 mg of tetracycline, or 100 mg of minocycline. Both tetracycline and minocycline are broad spectrum antibiotics and are very effective against periodontal pathogens. Furthermore both have substantivity, they bind to the tooth structure and are slowly released over time. The proper hydration of the alloderm will allow the removal of the cytoprotectants (that are used in the process of the freeze drying of the allograft) which in high concentration are toxic to the host cells.

b) Alloderm dimensions

The length and the width of the alloderm plays a very important role in the success of the procedure. The length of the alloderm should be trimmed lengthwise to the site's adjacent line angles. By extending the surgical site to the adjacent teeth not only increases the vascular blood supply to the graft by increasing the surface area of the periosteal vasculature, but also increases the stability of the graft. The vertical dimension of the graft should be about 8 mm.

c) Alloderm placement and stabilization

The ADM is placed in the pouch with the connective tissue side against the tooth surface, upon the recommendation of the manufacturer. A Younger Good curette is used to place the ADM into the pouch through the largest sulcus. The pouch should be passively advanced over the ADM to cover it completely. One of the key aspects in the recommended use of the Alloderm is that it should be completely covered with the pedicle flap unlike the autogenous connective tissue graft which can be left exposed.

d) Postoperative position of the gingival margin

According Pinti Prato et al³³ the post-surgical position of the coronally advanced flap plays an important role in achieving complete root coverage. According to the authors the coronal position of the margin 1-2 mm past the CEJ will ensure 100% root coverage. However this is not the case with the modified tunnel technique with alloderm. The design of the surgical procedure and the suturing technique recommended will ensure that there is no tissue retraction during the healing period. Therefore the excessive coronal advancement of the pedicle flap is not recommended. Furthermore the coronal advancement of 2 mm over the CEJ will create a dead space between the flap and the



Figure 11



Figure 12



Figure 13



Figure 14

tooth, diminishing the nourishment of the graft from the underlying periosteal bed. In order to avoid the formation of the death space that forms by coronally advancing the flap over the enamel, and the ADM + CAF should not be advanced beyond the CEJ of the tooth .

Key #8 and Key #9. Wound stability: Sutures and graft stabilization /retraction resistance

Wound healing is directly dependent upon the formation of a blood clot and the attachment of the of the clot to the root surface which is capable of withstanding mechanical forces acting on the interface between the flap and opposing wound surfaces. One critical factor in wound stability is the flap tension. Pinti Prato et al ³⁴ demonstrated that the higher the flap tension the lower the percentage of complete root coverage. The modified tunnel technique , features a full thickness combined with a split thickness flap elevation on the buccal surface area of the recession defect which ensures an ideal flap mobility as well as the preservation of the buccal blood supply . The modified minimally invasive tunnel technique described decreases the flap tension by extending the split thickness flap over 10 mm apical to the MGJ, deep into the mucosal tissues in order to gain mobility form the apical aspect and also by extending the surgical field to the adjacent teeth , and by elevating the interdental papilla, allowing for a passive coronal advancement of the flap. Other factors that are involved in retraction resistance are the use on non resorbable sutures (5.0 polypropylene sutures versus gut sutures) in a double sling method around each tooth , and the retention of the sutures until the graft is integrated (4-6 weeks). Subsequent modification in the suturing techniques focus on closure of the surgical wound. The double sling suture technique further stabilises and maintains the coronally advanced flap and the ADM but also provides a stable contact of the graft and the flap to the underlying periosteal bed. Furthermore, the single interrupted double sling suture is far more time efficient than the time consuming continuous sling sutures. With the use of the double sling suture technique the allograft and the pedicle graft are sutured together avoiding the initial fixation of the allograft first (with a chromic gut suture) and the coronal advancement of the pedicle flap with a subsequent polypropylene suture. The recommended suture for this procedure is either 5.0, .6.0 or 7.0 polypropylene suture. The braided or the gut sutures become contaminated with bacteria and can cause inflammation and irritation to the tissues. Furthermore the polypropylene suture has the ability to maintain the tension of the flap a lot longer than other sutures playing an important role in graft stabilisation during the healing period. A double sling single suture around each tooth helps in the graft stabilisation over time, if one the sutures around



Figure 15



Figure 16



Figure 17



Figure 18

the tooth becomes loose, the adjacent sutures will still be capable of maintaining the graft stability, preventing the movement of the ADM . Furthermore the sutures should be retained until the graft is integrated. Suture removal is usually scheduled at 4 - 6 week after the surgery.

10. Postoperative care

1. Analgesics are prescribed to control postoperative discomfort (Ibuprofen 600 mg four times a day for one week. Tylenol number 3 every six hours as needed)
2. Azytromycin (500 mg) is the antibiotic of choice for this procedure and it should be administered as follows two tables on the day of the surgery, two tablets one day after the surgery , and one tablet two days after the surgery.
3. To control the swelling dexamethasone is prescribed for four days :8 mg 2 hours before the surgery, 6 mg the next day, 4 mg the following day, and 2 mg the next day
4. Chlorhexidine gluconate 0.12% is prescribed twice per day for three week to control the plaque after the surgery.
5. No brushing or flossing for three weeks at the surgical site. Oral hygiene instructions and

professional cleaning to be performed at each follow up visit if indicated.

6. Ice for 24 hours
7. Inactivity for 24 hours followed by Light activity for 1 week
8. No mastication at the site for 2-3 weeks
9. Suture removal at 3-4 weeks post surgery

Conclusion

In recent years the modified tunnel flap procedure due to its atraumatic soft tissue management, preservation of the blood supply and predictable wound healing gained an increased usage in periodontal and implant surgery. Unfortunately there are too many variations of the procedure described. The present article describes not only the factors that are associated with the success of the procedure but also the surgical technique used in the clinical case described. ■

References available upon request.

Clinical Cases

Case 1



Pre operative view , recession associated with teeth number 11 21 22 23



Post operative



Alloder placed into the pouch



Maxillary left area, recession associated with teeth number 24 25 26



Maxillary right area (recession associated with teeth number 16 15 14)



Finish case

Case 2



Case 3



Case 4



Recession associated with tooth number 41



Alloderm pre measured , before placing it into the pouch (tunnel)

Case 5



Post operative



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