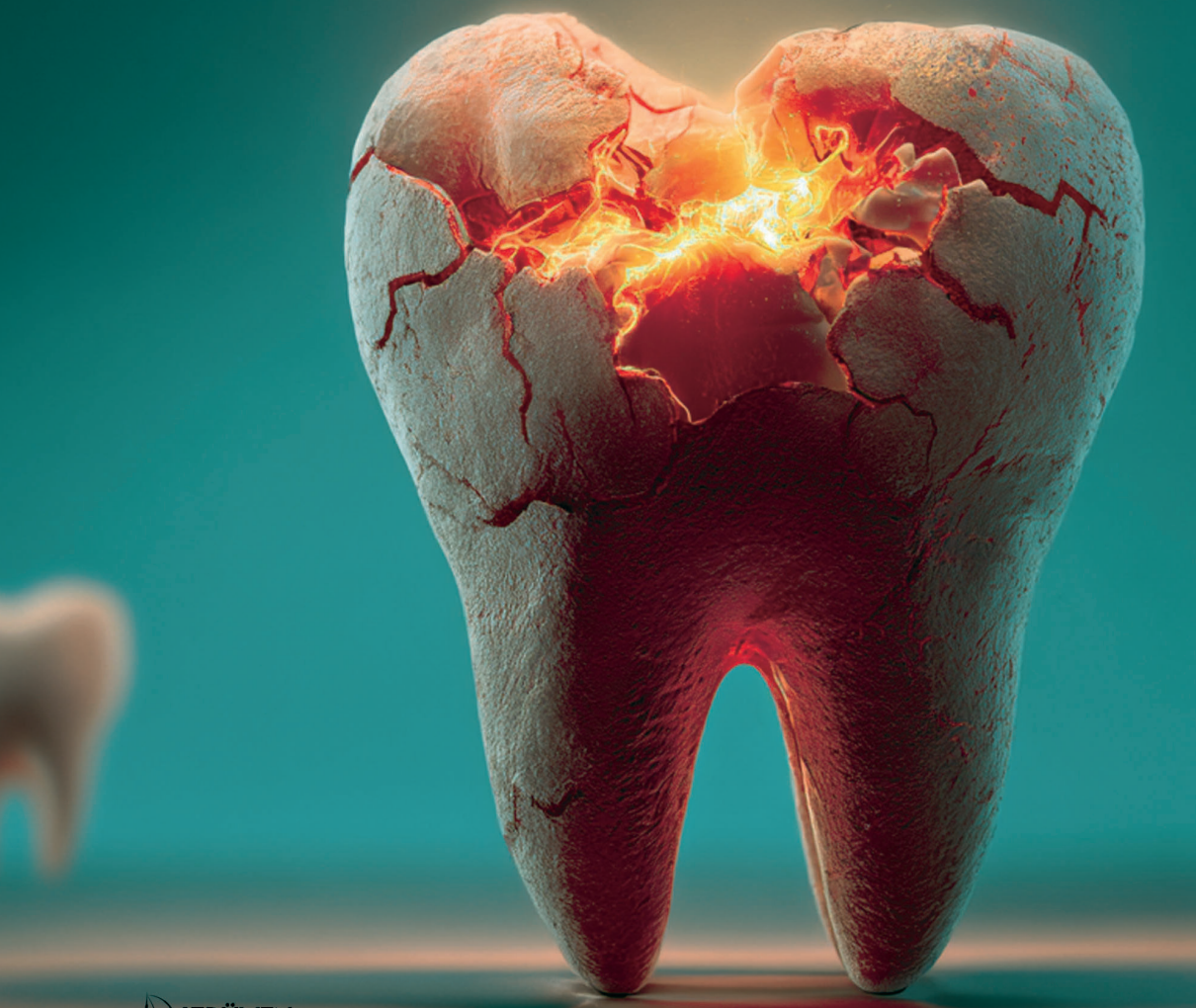
UZM. DT. MUHAMMED FURKAN ÖZCAN

INTERNATIONAL STUDIES IN PERIODONTICS, VOL. II



SERÜVEN YAYINEVİ

Genel Yayın Yönetmeni / Editor in Chief • C. Cansın Selin Temana

Kapak & İç Tasarım / Cover & Interior Design • Serüven Yayınevi

Birinci Basım / First Edition • © ARALIK 2025

ISBN • 978-625-5749-87-1

Serüven Yayınevi / Serüven Publishing
Türkiye Adres / Turkey Address: Kızılay Mah. Fevzi Çakmak 1. Sokak
Ümit Apt No: 22/A Çankaya/ANKARA
Telefon / Phone: 05437675765
web: www.seruvenyayinevi.com
e-mail: seruvenyayinevi@gmail.com

Baskı & Cilt / Printing & Volume
Sertifika / Certificate No: 47083

INTERNATIONAL STUDIES IN PERIODONTICS, VOL. II

DECEMBER 2025

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CONTENTS

PREFACE

Periodontology, as one of the core disciplines of dentistry, embodies the remarkable organization of human biology that becomes evident at every stage from diagnosis to treatment. Beyond its clinical applications, this field continues to attract great interest through its profound biological foundations and scientific depth.

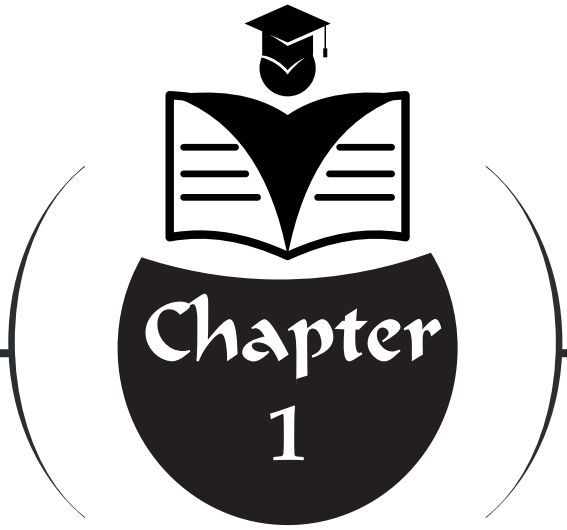
The conception of this book arose from my enduring curiosity and enthusiasm for periodontology, as well as from my aspiration to share knowledge and experience with colleagues, students, and researchers. I believe that the dissemination of scientific knowledge, the pursuit of lifelong learning, and the exchange of professional experience are essential elements that contribute to the collective advancement of our profession and humanity.

The process of preparing this book has been both scientifically enlightening and personally fulfilling. I am deeply grateful to my family for their constant encouragement and unwavering support throughout this endeavor.

I dedicate this work to all those who have inspired and guided me on my academic journey especially my family, my professors, and my esteemed colleagues.

Muhammed Furkan ÖZCAN

Ankara, December 2025



DENTAL IMPLANTS PLACED IN THE ESTHETIC ZONE

Aesthetics has increasingly become a significant concept over time, and it has been emphasized that treatment planning following tooth loss should address not only functional requirements but also patients' esthetic expectations. (Stefanini et al., 2018) The concept of aesthetics is evaluated from both subjective and objective perspectives. (Zitzmann et al., 2002) In dental treatments, it is crucial that the outcomes primarily fulfill objective esthetic criteria while also meeting the patient's individual, subjective demands. (Evlioğlu Gülümser, 2022) However, esthetic expectations may differ between the patient and the clinician. (Langlois et al., 2000)

Evaluation in Terms of Soft Tissue

Dental implants differ from natural teeth in terms of morphological and biological characteristics, which also affects the peri-implant soft tissue configuration. (Traini et al., 2005) Despite the presence of clinically healthy gingiva, loss of papilla and mucosal irregularities may compromise the esthetic outcome. (Tischler, 2004) Implant-supported restorations in the esthetic zone must be in harmony with adjacent natural teeth in terms of symmetry, gingival contour, papillary form, and position. (Chow & Wang, 2010) Therefore, a comprehensive assessment of both the hard and soft tissue conditions of the edentulous site and the periodontal health of neighboring teeth is essential in the planning phase.

The periodontal status of adjacent teeth directly influences the success and long-term stability of implant therapy. Accordingly, a detailed evaluation of the patient's oral hygiene should be performed and improved if necessary to enhance implant survival. (Atala, Ustaoğlu & Çetin, 2019) Moreover, probing depths of teeth adjacent to the edentulous area should also be assessed. This measurement not only provides information about periodontal health but also helps in predicting esthetic outcomes of the planned restoration. Achieving a natural-looking papilla between the implant and adjacent teeth is closely related to the interproximal attachment levels; thus, these levels should be carefully analyzed. (Chow & Wang, 2010)

To optimize esthetic outcomes, various approaches may be employed, including atraumatic tooth extraction, grafting and membrane placement, ridge preservation procedures, immediate implant placement, flapless surgery, papilla-preserving flap designs, and soft tissue grafting. In addition to restorative and prosthetic interventions, non-surgical methods such as orthodontic extrusion can also contribute positively to papillary morphology. (Chow & Wang, 2010)

The Impact of Periodontal Phenotype on Anterior Implant Success and Alternative Approaches

One of the critical factors influencing the success of implant therapy in the anterior region is the patient's soft tissue biotype. In the literature, peri-dental soft tissues are classified into two main biotypes: thick and thin. (Khajuria, Bhatnagar & Bhardwaj, 2023) Individuals with a thin biotype generally exhibit triangular-shaped crowns, whereas square-shaped crowns are commonly observed in those with a thick biotype. In areas with a thick gingival biotype, the marginal bone tends to be more robust, contact points are located more apically, and the soft tissue typically presents a flatter architecture. Conversely, in the thin biotype, contact points are positioned closer to the incisal edge, are narrower, and the soft tissue architecture is more scalloped. Furthermore, individuals with a thin biotype are more prone to alveolar defects such as fenestrations and dehiscences. In terms of crown morphology, less cervical convexity is observed in the thin biotype, while the thick biotype is characterized by a more pronounced convexity. Gingival recession is more prevalent among patients with a thin biotype, whereas the formation of periodontal pockets is more frequently associated with a thick biotype. (Khajuria, Bhatnagar & Bhardwaj, 2023)

Following the new classification introduced in 2017, the term *"periodontal phenotype"* has been recommended in place of *"gingival biotype."* (Dds et al., 2021) Studies have demonstrated that a thick periodontal phenotype is more advantageous for improving both surgical and prosthetic treatment outcomes. (Linkevicius, Apse & Grybauskas, 2009) Moreover, higher incidences of gingival recession have been reported following implant placement in individuals with a thin phenotype. In contrast, regions with a thick phenotype present with denser alveolar bone and greater cortical support, positively contributing to implant success. (Ferrus, Cecchinato & Lang, 2009)

Research has shown that hard tissue augmentations can increase peri-implant tissue volume by approximately 57%, whereas soft tissue augmentations contribute about 43%. (Schneider et al., 2010) The decision regarding the timing of soft tissue reconstruction—whether before, during, or after surgery—must be made carefully. (Schneider et al., 2010) Especially in cases involving multiple missing teeth, pink esthetics may serve as a viable alternative to conventional augmentation procedures. (Mitrani, 2005)

During treatment planning, a comprehensive assessment should include the patient's general health status, smoking habits, esthetic expectations, smile line, maxilla-mandibular relationships, oral hygiene status, periodontal attachment levels, tissue phenotype, and existing dentition. (Ramanauskaite & Sader, 2022; Tischler, 2004) Following this evaluation, not only implant surgery but also other potential treatment options should be considered.

Particularly in esthetically critical zones, alternatives to implant therapy may include removable partial dentures, resin-bonded bridges, cantilever-supported fixed prostheses, tooth-supported overdentures, and orthodontic space closure. (Tischler, 2004; Levine et al., 2017)

Management of Extraction Sites and the Healing Process

Alveolar healing following tooth extraction is a dynamic process consisting of sequential biological phases. Effective management of this process is crucial for planning a successful treatment that meets both functional and aesthetic expectations.

Hemostasis Phase

The first 24 hours following tooth extraction are referred to as the hemostasis phase. During this period, the extraction socket fills with blood, and a clot containing various proteins forms following hemorrhage. In the absence of systemic or local conditions that may impair healing, this clot stabilizes over time. The stabilized clot serves as a physical matrix for the migration and proliferation of surrounding cells, thus initiating the healing process. (Atat et al., 2014)

Inflammation Phase

The inflammation phase spans approximately from 24 hours to 4 weeks post-extraction. Following clot formation, inflammatory cells migrate to the site. These cells not only facilitate the degradation of the transient extracellular matrix but also contribute to the regulation of the anti-inflammatory response. (Atat et al., 2014) During this phase, pronounced osteoclastic activity is observed, particularly in the crestal region. Moreover, rapid migration of epithelial and connective tissues toward the extraction socket has been reported. (Schneider et al., 2010)

Proliferative Phase

The proliferative phase typically occurs between the third and fourteenth weeks of healing. During this phase, mineralization of the osteoid tissue formed at the base of the socket progresses coronally. By the sixth week following extraction, re-epithelialization of the socket is generally complete. (Atat et al., 2014) Maximum radiographic bone density and maturation are usually achieved by the twelfth week; however, the regenerated bone rarely reaches the alveolar level of adjacent teeth in terms of density. (Darby, Chen & Poi, 2008)

Morphological Changes

At the end of the healing process, occlusal views of extraction sites often reveal a shift of the alveolar crest in the lingual direction. This is attributed to the buccal cortical bone being more susceptible to resorptive changes. (Araújo & Lindhe, 2005)

Preservation of Alveolar Bone

Preservation of the alveolar bone following tooth extraction is critical for preventing resorption and maintaining both aesthetic and functional integrity. Alveolar ridge preservation can be achieved using different techniques aimed at minimizing post-extraction volume loss. Three principal methods have been described in the literature for this purpose: (Atat et al., 2014; Verma, Lata & Kaur, 2019)

✓ **Partial extraction protocols (socket-shield technique):** Preservation of the buccal root segment during extraction.

✓ **Orthodontic extrusion:** Controlled orthodontic forces applied to elevate the tooth coronally before extraction.

✓ **Alveolar grafting:** Filling the extraction socket with biomaterials for support.

In addition to these methods, the use of autologous blood derivatives rich in growth factors (e.g., PRF) has been increasingly recommended in recent years. (Jafer et al., 2022) Currently, the most commonly applied approach is the use of graft materials to fill the extraction socket.

The advantages of this technique can be summarized as follows:

✓ Relatively low technical sensitivity

✓ Predictable clinical outcomes

✓ Time efficiency in surgical procedures

Alveolar ridge preservation procedures are particularly recommended in the following clinical scenarios:

✓ Buccal bone thickness less than 1.5 - 2 mm in the anterior region

✓ Patients with a high smile line

✓ Individuals with a thin gingival phenotype and a risk of post-extraction gingival resorption

✓ Cases involving the planned extraction of multiple adjacent teeth (Darby, Chen & Poi, 2008)

In such cases, appropriate surgical preservation strategies help prevent advanced hard and soft tissue loss, thereby facilitating optimal anatomical conditions for implant placement and enhancing esthetic outcomes.

Socket Grafting

In alveolar ridge preservation procedures, bone grafts can be utilized alone or in combination with barrier membranes. Autogenous bone grafts are considered the gold standard due to their osteogenic, osteoinductive, and osteoconductive properties. These grafts are typically harvested from intraoral donor sites such as the maxillary tuberosity, edentulous alveolar ridges, mandibular ramus, and symphysis region. Allogeneic grafts, while possessing osteoinductive potential, carry a risk of eliciting immunogenic responses. Additionally, xenogeneic grafts derived from various animal species are also employed for socket grafting purposes. (Jafer et al., 2022) All of these graft types exhibit osteoconductive characteristics. The slow resorption rate of xenografts, in particular, makes them advantageous in preserving post-extraction alveolar volume. (Dawson, 2016)

Systematic reviews evaluating the efficacy of bone graft materials in socket preservation have reported that, compared to extraction-only sites, the application of grafts provides an average of approximately 2 mm of tissue volume gain in the buccolingual dimension, as well as up to 2 mm at the mid-buccal level. (Vignoletti et al., 2011; Dawson, 2016)

The concomitant use of collagen membranes with bone grafts offers several advantages during the healing process. These membranes prevent soft tissue invasion into the grafted socket space, thereby establishing a suitable environment for bone regeneration. Furthermore, they contribute to the stabilization of the graft material and act as a barrier against the ingress of oral microorganisms into the extraction socket. (Arau, 2009)

In addition to these materials, autologous blood-derived products such as platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) have demonstrated supportive effects on hemostasis and play a role in accelerating wound healing and bone regeneration when applied locally. (Jafer et al., 2022)

Immediate Implant Placement (IIP)

The immediate implant placement protocol was first proposed in 1978 as an alternative to conventional implant procedures and was subsequently introduced into the literature by Lazzara. (Lazzara, 1989) In this technique, primary implant stability is achieved through engagement with the existing bone in the apical portion of the extraction socket or within the interradicular area. (Koh, Rudek & Wang, 2010)

Advantages (Lazzara, 1989; Angelis et al., 2021; Stephen et al., 2009)	·	Reduction of treatment duration
	·	The ability to use the natural socket anatomy as a guide
	·	Being less invasive due to flapless surgery, thereby causing minimal trauma to the soft tissues
	·	Meeting the patient's functional, aesthetic, and phonetic needs through the placement of a provisional restoration in the same session
	·	Guiding the soft tissue profile through the use of a provisional restoration

Disadvantages (Meng, Chien, & Chien, 2021; Stefanini et al., 2023)	·	Requires high technical precision
	·	In some cases, primary stability may not be achievable
	·	The potential need for additional grafting
	·	Unpredictability of hard and soft tissue levels

Guided Surgical Planning and Long-Term Outcomes of Immediate Implant Placement

In order to achieve ideal implant positioning, it is recommended that surgical procedures be planned using guided systems. Within this context, computer-assisted surgical planning software should be utilized, and instead of a flapless approach, elevation of a buccal flap is suggested to provide an adequate field of view and facilitate soft tissue manipulation. (Stefanini et al., 2023)

In a systematic review published in 2015 involving approximately 2,000 implants, the survival rate of immediately placed and provisionally restored implants in the esthetic zone was reported to be 97.6%. (Fabbro et al., 2015) Furthermore, a clinical study conducted in 2020 reported a 10-year survival rate of 90.9% following immediate implant placement in the anterior region. The same study demonstrated comparable marginal bone loss at 5 and 10 years, with a mean bone loss of 0.31 mm measured at the end of the 10-year period. (Seyssens & Eghbali, 2020)

According to a review published in 2021, preservation of the buccal bone wall after tooth extraction and a thick soft tissue phenotype are critical for minimizing marginal bone loss following immediate implant placement.

Additionally, it is recommended that implants be positioned as far palatally as possible, following the curvature of the alveolar ridge, and that the gap between the socket and the implant be filled with grafting material. Soft tissue thickness should be increased using a connective tissue graft (CTG). (Angelis et al., 2021)

Clinical and histologic studies by Nevins and Parma-Benfenati (2018) reported that the bone-to-implant contact (BIC) ratio in immediately placed implants was 66.2%, which is approximately 10% lower than that observed in implants placed into healed sites. Therefore, it is essential to thoroughly assess for the presence of periapical infections, the need for grafting, and the appropriate loading protocol before proceeding with immediate implant placement.

In a study by Tsigarida et al. (2020), buccal bone thickness in the maxillary anterior region was evaluated, and it was found that in the majority of cases, the buccal bone wall was thinner than 1 mm. Furthermore, the buccal bone of central and lateral incisors was thinner compared to canines and showed an apical increase in thickness. The amount of buccal bone resorption observed during the first four months following immediate implant placement was found to be directly related to the initial alveolar ridge thickness. Sites with a baseline bone thickness greater than 1 mm demonstrated significantly less resorption. In addition, a minimum soft tissue thickness of 3 mm has been reported to be necessary for the formation of a stable peri-implant epithelial attachment. (Ferrus, Cecchinato & Lang, 2009)

In conclusion, the thickness of hard and soft tissues in the target region should be carefully evaluated prior to immediate implant placement. In cases where these tissues are deficient, it is advisable to postpone implant surgery and consider placement following appropriate augmentation procedures. (Khajuria, Bhatnagar & Bhardwaj, 2023)

Provisional Restorations

One of the major advantages of the immediate implant placement protocol is the ability to deliver provisional restorations that support the peri-implant soft tissues. These restorations offer several clinical and biological benefits:

Advantages	·	Maintains the stability of peri-implant mucosal tissues.
	·	Contributes to the temporary restoration of esthetic, phonetic, and occlusal functions prior to the completion of definitive implant restorations. (Santosa, 2007)
	·	Supports the continuity of the papillary structure.
	·	Facilitates soft tissue guidance by creating an emergence profile that conforms to the natural contours of the extracted tooth.
	·	Contributes to the stability of the blood clot during the healing process.

Provisional restorations not only aid in shaping the soft tissue profile but also facilitate communication between the clinician and dental laboratory, thereby guiding the design of the final restoration. (Priest, 2006; Pitman, Christiaens, & Cosyn, 2022)

In a review conducted by Sutariya et al. (2022), immediate implants placed in the esthetic zone along with provisional restorations delivered at the same appointment were reported to provide moderate evidence for minimizing post-extraction peri-implant soft tissue changes. Following immediate implant placement, both screw-retained and cement-retained provisional restorations can be utilized. Although cement-retained restorations offer ease of fabrication, they are also associated with complications such as foreign body reactions due to excess cement and risk of decementation. (Levine et al., 2017) Implant restorations in the esthetic zone are commonly subjected to obliquely directed occlusal forces, which may result in complications such as screw loosening or restoration fracture. Therefore, ensuring that provisional restorations are free of occlusal contact is essential for minimizing such biomechanical risks. (Levine et al., 2017)

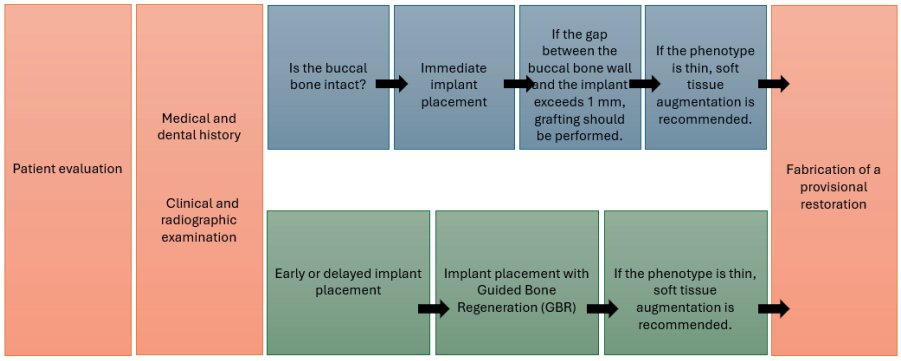


Figure 1. *Workflow in immediate implant planning (IIP)*

Early and Delayed Implant Placement

Implant placement performed within 4 to 8 weeks following tooth extraction—allowing for soft tissue healing—is defined as early implant

placement. The main advantages of this protocol include a lower incidence of gingival recession, preservation of the buccal cortical bone, and the gain of 3 to 5 mm of keratinized tissue due to improved soft tissue conditions. (Puisys et al., 2022; Buser et al., 2017)

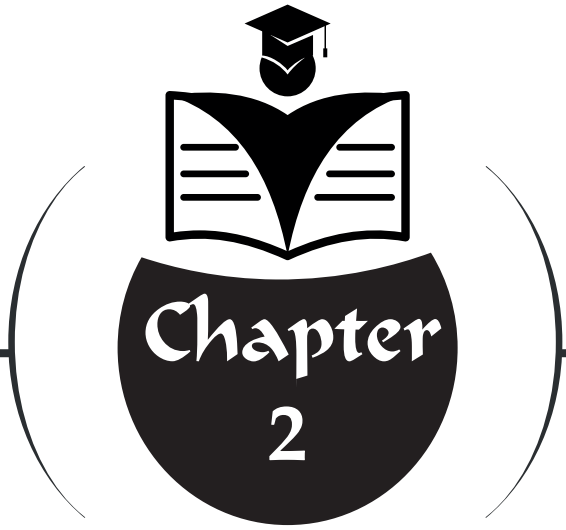
In addition, any acute or chronic infections that may be present in the extraction site can be resolved during this interval, and the initiation of new bone formation in the apical region of the socket can contribute to enhanced primary stability. This provides a biomechanical advantage to the early placement protocol compared to immediate implant placement. (Buser et al., 2017)

Implant Placement Protocols According to Timing

Early Implant Placement	*Late-Stage Implant Placement*
(4 to 8 weeks post-extraction)	(Placement ≥ 6 months post-extraction)

Partial alveolar bone healing is generally achieved within 12 to 16 weeks post-extraction, after which early implant placement can be performed. This approach is particularly preferred in cases where extensive periapical lesions hinder ideal implant positioning. Additionally, it is considered more suitable in anatomical regions with multi-rooted teeth, such as the mandibular first molar area. (Buser et al., 2017)

Late implant placement is typically carried out after a minimum healing period of 6 months following extraction. This protocol is indicated in cases of traumatic tooth loss, in patients with ongoing growth and development, and in pregnant individuals. In all these indications, socket grafting is recommended to prevent volume loss and to create sufficient bone volume for implant placement. (Buser et al., 2017)



NON-SURGICAL TREATMENT APPROACHES FOR PERI-IMPLANT DISEASES

The primary objective in the treatment of peri-implant diseases is the elimination of the microbial biofilm and the reduction of the bacterial load in the peri-implant region. (Lang et al., 2004) In this context, a therapeutic protocol has been developed to prevent the progression of peri-implant lesions. Termed "Cumulative Interceptive Supportive Therapy (CIST)," this protocol comprises a four-phase treatment sequence offering progressively increasing antibacterial intervention, depending on the extent and severity of the lesion. (Lang, Wilson, and Corbet, 2000)

Clinical Assessment Parameters	✓ Presence of dental plaque ✓ Mild bleeding on probing ✓ Presence of suppuration ✓ Peri-implant probing depth ✓ Presence of radiographic bone loss

Mechanical Debridement (Supportive Treatment Protocol A)	✓ No treatment is required in cases where probing depth is ≤3 mm and neither bleeding nor plaque accumulation is observed. (Lang et al., 2004) ✓ However, mechanical debridement is indicated in peri-implant tissues with probing depths not exceeding 3 mm that exhibit plaque and calculus accumulation accompanied by mild inflammation (+ bleeding). ✓ For this purpose, carbon fiber curettes, silicone polishing strips, and polishing pastes can be utilized. ✓ Carbon fiber curettes enable the removal of deposits without damaging the implant surface. ✓ Conventional steel curettes and metal-tipped ultrasonic instruments are not recommended, as they may cause microscopic damage to the surface, thereby promoting plaque retention. (Lang, Wilson, and Corbet, 2000)

Antiseptic Therapy (Supportive Treatment Protocol B)	✓ In addition to mechanical debridement, antiseptic therapy is applied in cases with probing depths between 4 and 5 mm, accompanied by plaque accumulation and bleeding. ✓ The presence of suppuration may vary. ✓ Chlorhexidine digluconate (CHG) is the most commonly used agent. ✓ It is recommended to be applied as a mouth rinse or topical gel at concentrations of 0.1% to 0.2% for a duration of 3 to 4 weeks. ✓ This method provides effective support for chemical plaque control. (Lang, Wilson, and Corbet, 2000)
Antibiotic Therapy (Supportive Treatment Protocol C)	✓ Systemic antibiotic therapy may be required for lesions with probing depths ≥6 mm, accompanied by bleeding and frequently suppuration, and radiographically evident bone loss. ✓ These lesions provide a suitable environment for the colonization of gram-negative anaerobic microorganisms. ✓ Mechanical and antiseptic treatments must be completed prior to initiating antibacterial therapy. ✓ It is recommended to commence antibiotic therapy with agents such as metronidazole or ornidazole during the last 10 days of antiseptic application. ✓ This protocol supports soft tissue healing while also including prophylactic measures aimed at preventing infection recurrence. (Lang, Wilson, and Corbet, 2000)
Regenerative or Resective Surgery (Supportive Treatment Protocol D)	✓ Regenerative or resective surgical treatments are indicated for cases with probing depths ≥5 mm and radiographically detected bone loss of ≥2 mm. ✓ For the application of this protocol, mechanical debridement, antiseptic, and antibiotic treatment protocols must first be thoroughly completed and the infection controlled. ✓ The choice of surgical technique is determined based on the morphology of the existing bone defect. (Lang, Wilson, and Corbet, 2000)

Table 1. *Cumulative Interceptive Supportive Therapy (CIST)*

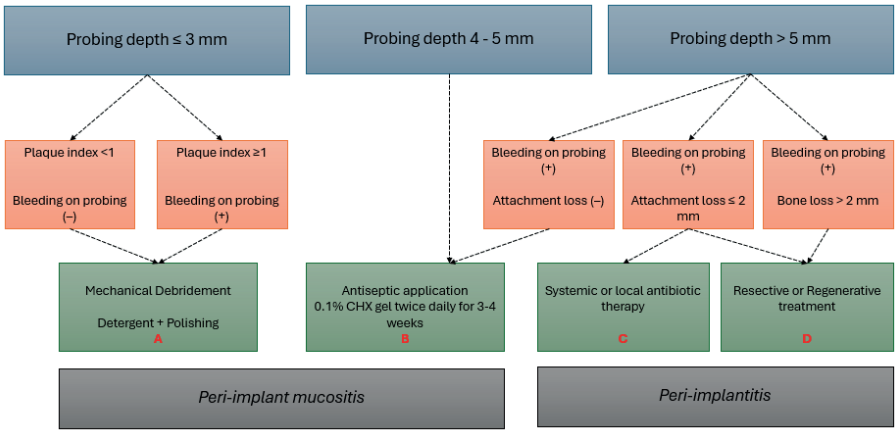


Figure 1. *Workflow for peri-implant mucositis and peri-implantitis treatment. (Lang, Wilson ve Corbet, 2000)*

Peri-implant Mucositis

Peri-implant mucositis is a reversible inflammatory condition that primarily develops as a result of dental plaque accumulation. (Berglundh, Mombelli, Schwarz, & Derks, 2024) Its management may include professional methods - with or without the adjunctive use of antimicrobial agents - alongside home-based oral hygiene protocols. The fundamental approach in treatment involves mechanical debridement of supragingival and subgingival biofilm accumulated on the implant surface and at the implant-abutment interface. (Figuero et al., 2014)

The primary objective of mechanical therapy is to re-establish a healthy peri-implant mucosa by eliminating the biofilm without damaging the implant surface. (Figuero et al., 2014; Renvert et al., 2019) Even in the absence of antimicrobial agents, professional mechanical interventions have been reported to significantly reduce inflammation. This indicates that mechanical treatment alone may be effective, provided that the patient maintains adequate oral hygiene. (Figuero et al., 2014) However, the adjunctive use of antimicrobial agents has also been shown to enhance the clinical efficacy of mechanical therapy. (Renvert, Roos-Jansåker, & Claffey, 2008)

Various curettes (steel, titanium-coated, plastic, teflon, or carbon fiber) and ultrasonic devices can be used during mechanical debridement. However, it has been demonstrated that steel curettes and standard ultrasonic tips may cause microscopic damage to the implant surface. Therefore, to preserve surface integrity, the use of titanium or carbon fiber curettes and specially designed ultrasonic tips is recommended. (Speelman, Collaert, & Klinge,

1992; Schenk et al., 1997; Mann et al., 2012; Warreth et al., 2015; Renvert & Polyzois, 2015) Additionally, for surface finishing, polishing with silicone rubber cups and paste or air powder systems containing sodium bicarbonate may be advised. (Figuero et al., 2014)

As an adjunctive treatment modality, laser therapy can also be employed. Although it does not show a clear advantage over conventional methods, laser treatment has been reported to yield more favorable clinical outcomes in peri-implant mucositis compared to peri-implantitis cases. (Saneja et al., 2020)

Finally, effective home-based mechanical plaque control and oral hygiene practices are of paramount importance for the successful management of peri-implant mucositis and for preventing recurrence. (Figuero et al., 2014)

Non-Surgical Treatment of Peri-Implant Diseases

Peri-implantitis is considered an inflammatory disease primarily associated with dental plaque and is thought to develop as a progression of untreated peri-implant mucositis. (Berglundh, Mombelli, Schwarz, & Derks, 2024) Therefore, the first step in the treatment of peri-implantitis involves the mechanical debridement of supragingival and subgingival bacterial accumulations around the implant.

Drawing from treatment approaches used in periodontitis, various non-surgical treatment protocols have been proposed for peri-implantitis as well. (Hong et al., 2024) These protocols, which resemble those employed in the management of peri-implant mucositis and periodontitis-affected teeth, form the foundation of non-surgical management of peri-implantitis. (Smeets et al., 2014) This is attributed to the similarities in microbial colonization processes on tooth and implant surfaces, and the critical role of biofilm in the pathogenesis of peri-implant inflammation. (Smeets et al., 2014)

The primary objective of non-surgical peri-implantitis treatment is to reduce or completely eliminate probing depth and bleeding on probing by mechanically decontaminating the implant surface. (Schenk et al., 1997; Berglundh, Mombelli, Schwarz, & Derks, 2024) However, in advanced cases, disease resolution is typically not achievable through non-surgical means alone. Nevertheless, non-surgical approaches should always be the first step in the treatment of peri-implantitis. (Renvert et al., 2019)

Historically, the non-surgical treatment of peri-implantitis was considered to have limited efficacy, mainly due to the difficulty of accessing contaminated implant surfaces. However, the adjunctive use of systemic or local antibiotics has been reported to enhance the effectiveness of these interventions and result in higher success rates. (Hong et al., 2024)

Non-Surgical Treatment Methods Used in Peri-Implantitis	✓	Mechanical debridement
	✓	Local or systemic antibiotic therapy
	✓	Laser applications
	✓	Antimicrobial photodynamic therapy
	✓	Powder-air abrasive systems (air-abrasive devices)
	✓	Antiseptics (CHX, H_2O_2, saline, etc.)
	✓	Ultrasonic devices
	✓	Probiotics
	✓	Oral hygiene measures (O.H.M.)

Although non-surgical treatment modalities are generally considered to have limited effectiveness in the complete elimination of peri-implantitis, they are often associated with significant reductions in bleeding on probing and probing pocket depth. (Rokaya et al., 2020; Zhao et al., 2022)

Mechanical Treatment

While mechanical treatment is considered an effective approach for the management of peri-implant mucositis, it demonstrates limited success in the treatment of peri-implantitis. (Lindhe & Meyle, 2008) This limitation is attributed to factors such as implant surface characteristics, implant design, and the type of prosthetic components, which may compromise the efficacy of non-surgical mechanical debridement procedures. (Renvert & Polyzois, 2015) Since mechanical debridement alone may be insufficient to completely eliminate microbial contamination, it is recommended to combine it with antiseptic agents, antimicrobial therapies, laser applications, or surgical interventions. (Rokaya et al., 2020)

Mechanical debridement for plaque control can be performed using various instruments, including stainless steel, Teflon, carbon fiber, titanium, or plastic curettes, metal-tipped ultrasonic scalers, titanium rotary brushes, and air-abrasive systems. (Bertoldi et al., 2017; Rokaya et al., 2020) However, studies on peri-implant mucositis have reported that metal curettes and standard ultrasonic tips may damage implant surfaces. Therefore, the use of titanium or carbon fiber curettes, or specially designed ultrasonic tips that cause minimal harm to the implant surface, is recommended. (Mann et al., 2012; Warreth et al., 2015; Renvert & Polyzois, 2015)

Ultrasonic devices have been shown to be as effective as hand instruments in removing microbial biofilm from implant surfaces and are widely used in implant debridement (Kormas et al., 2020). The tips of these devices are made of carbon fiber, silicone, or plastic and are biomechanically compatible with implant surfaces. (Figuero et al., 2014) Similarly, rotary titanium

brushes present an effective alternative for implant surface decontamination. (Sirinirund, Garaicoa-Pazmino, & Wang, 2019)

Although mechanical debridement can also be performed with conventional curettes, it is emphasized that the material hardness of the curette should be lower than that of titanium in order to avoid altering the roughness of the implant surface. (Smeets et al., 2014)

Types of Curettes

Specially designed curettes made from various materials have been developed for the debridement of implant surfaces: (Figuero et al., 2014)

- **Steel curettes:** Due to their higher surface hardness compared to titanium, steel curettes should not be used on titanium implant surfaces. However, they may be suitable for implants with surface coatings composed of harder materials such as titanium oxynitride or titanium zirconium oxide.
- **Titanium-coated curettes:** These instruments have a surface hardness similar to that of titanium and can therefore be safely used without scratching the implant surface.
- **Plastic curettes:** Among the most fragile types, plastic curettes have limited effectiveness in mechanical debridement but may be preferred for use on delicate surfaces.
- **Carbon fiber curettes:** Softer than implant surfaces, these curettes are prone to fracture; nevertheless, they enable effective removal of contaminants without damaging the implant surface.
- **Teflon curettes:** Sharing similar properties with carbon fiber curettes, Teflon curettes are often recommended for use in conjunction with air-abrasive systems.

Antibacterial Photodynamic Therapy (aPDT)

Peri-implant diseases arise from polymicrobial colonization on peri-implant tissues and implant surfaces. One of the critical steps in managing these diseases is the decontamination of the implant surface. Among the methods used for this purpose is antibacterial photodynamic therapy (aPDT). (Rahman et al., 2022) Photodynamic therapy has emerged as an increasingly popular and innovative approach in the management of peri-implant diseases. (Raghavendra, Koregol, & Bhola, 2009)

Advantages (Raghavendra et al., 2009)	✓ Rapid bacterial elimination
	✓ Prevention of antimicrobial resistance development
	✓ Preservation of normal oral flora and host tissues

Antibacterial Photodynamic Therapy (aPDT) relies on the generation of reactive oxygen species through the combined use of a photosensitizer—such as toluidine blue—and high-energy, single-wavelength light (e.g., diode laser). In a study conducted by Deppe et al. (2013), the application of aPDT in moderate to advanced peri-implantitis cases resulted in improvements in clinical attachment levels and reductions in bleeding index.

Photodynamic therapy has also been shown to produce clinical outcomes comparable to those of adjunctive local antibiotic therapy when combined with mechanical debridement. (Schär et al., 2013; Bassetti, Schär, & Wicki, 2014) One of the main advantages of this method is its ability to exert bactericidal effects without causing damage to surrounding tissues and with a low risk of inducing microbial resistance. Moreover, the type of photosensitizer used is a critical determinant of treatment success. (Zhao et al., 2022)

Therapeutic efficacy may be influenced by several factors, including the presence of exudate, the concentration of the photosensitizer, dye penetration, irradiation time, subgingival pH, the type of light source used, and the applied energy density. (Rahman et al., 2022)

Laser Applications

Decontamination of the implant surface is a primary goal in the treatment of peri-implantitis. (Konstantinidis et al., 2015) Laser technology is one of the adjunctive methods utilized for this purpose. (Lerario et al., 2015) Lasers can access implant surface areas that are unreachable by mechanical instruments and exert effective decontaminating and bactericidal effects in those regions. (Schwarz et al., 2006) Additionally, lasers offer several clinical benefits, including promotion of regeneration, decontamination, and acceleration of the healing process.

One of the reasons lasers are preferred is their association with reduced bleeding compared to conventional mechanical techniques. (Smeets et al., 2014) The clinical outcomes achieved through the use of lasers alone have been shown to be comparable to those obtained with air-abrasive systems. (Renvert et al., 2011) Furthermore, it has been reported that the adjunctive use of lasers with mechanical debridement yields superior clinical results compared to mechanical treatment alone. (Mettraux et al., 2016)

However, some drawbacks of laser applications have also been noted. Certain laser types may cause deformation of the implant surface (Warreth et al., 2015), and the resulting increase in surface roughness may promote plaque retention. (Rimondini et al., 1997) Overall, lasers are reported to have limited but favorable effects in the treatment of peri-implantitis, and the need for further research in this field is frequently emphasized. (Renvert & Polyzois, 2015)

Among the laser types used in peri-implantitis treatment are Nd:YAG, Er:YAG, CO_2, and diode lasers, with Er:YAG lasers being the most commonly and safely used. (Renvert & Polyzois, 2015; Zhao et al., 2022)

Er:YAG Laser

Er:YAG lasers are capable of effectively and safely removing dental calculus. (Renvert & Polyzois, 2015) They can also be used for excising both soft and hard oral tissues and support bone tissue regeneration. Additionally, these lasers exhibit bacteriostatic and antiseptic effects against pathogenic microorganisms in peri-implantitis sites. (Zhao et al., 2022)

Diode Laser

Diode lasers have been successfully used in the non-surgical treatment of peri-implantitis. (Schär et al., 2013) When used for decontamination, they have been shown to produce effective results without damaging surrounding tissues or interacting negatively with titanium surfaces. (Romanos, Everts, & Nentwig, 2000) Moreover, these lasers contribute to the reduction of peri-implant mucosal inflammation and improvement in probing depths. (Schär et al., 2013)

Antibiotics

Antibiotics are effective pharmacological agents for controlling infections. (Rokaya, Srimaneepong, Wisitrasameewon, Humagain, & Thunyakitpisal, 2020) While mechanical debridement remains the cornerstone of peri-implant infection treatment, it may not be sufficient for complete elimination of the bacterial load. Therefore, the use of antibiotics as an adjunct to mechanical therapy is recommended. (Figuero, Graziani, Sanz, Herrera, & Sanz, 2014) However, antibiotics should not be considered a standalone treatment modality, but rather as a supportive approach to mechanical debridement. (Smeets et al., 2014)

Antibiotics can be administered either systemically or locally. (Rokaya et al., 2020) The goal of local antibiotic application is to enhance the antibacterial efficacy of mechanical debridement and to prevent bacterial recolonization

on the implant surface. (Figuero et al., 2014) The most commonly used local antibiotics in peri-implantitis treatment include doxycycline, minocycline, cefazolin, and gentamicin. In moderate peri-implantitis cases, the application of local minocycline or doxycycline following mechanical debridement has been shown to enhance therapeutic outcomes. (Rokaya et al., 2020)

In a systematic review by Toledano et al. (2021), patients treated with local antibiotics demonstrated significantly greater reductions in peri-implant probing depths and bleeding indices compared to control groups. The aim of systemic antibiotic administration is to provide a therapeutic level of antibacterial activity in the peri-implant crevicular fluid, in addition to mechanical debridement. In this context, a commonly recommended systemic protocol involves the administration of 500 mg azithromycin daily for four days. (Figuero et al., 2014)

The literature also suggests that combined use of systemic and local antibiotics may positively influence treatment outcomes. (Rokaya et al., 2020) However, prolonged antibiotic use increases the risk of opportunistic infections (superinfections) and poses a serious complication in peri-implantitis therapy. (Verdugo, Laksmana, & Uribarri, 2016) Furthermore, due to the global concern over rising antibiotic resistance, antibiotic use in routine peri-implantitis treatment should be approached with caution. (Grusovin et al., 2022)

Air - Abrasive Systems

Conventional air-abrasive systems employ sodium bicarbonate ($NaHCO_3$) particles delivered via pressurized air and are primarily used for stain removal and polishing procedures on tooth surfaces. However, due to their highly abrasive nature, these systems pose a risk of damaging implant surfaces and are therefore considered unsuitable for implant instrumentation. In recent years, the use of air-abrasive systems with glycine powder has become increasingly prevalent for debridement around implants. Glycine is characterized by a lower abrasiveness and has been shown to effectively remove biofilm from implant surfaces without causing harm to the surrounding soft and hard tissues. (Figuero et al., 2014)

In a study conducted by Keim et al. (2019), air-abrasion with glycine powder was reported to cause less surface alteration and achieve greater cleaning efficacy compared to hand instruments and ultrasonic devices. Although air-abrasive systems used for mechanical debridement are not associated with implant surface damage, they have been reported to pose a risk for subcutaneous emphysema. (Renvert, Polyzois & Claffey, 2012) Furthermore, their use in subgingival areas should be approached with caution due to the potential for soft tissue trauma. (Schwarz, Becker & Renvert, 2015)

Antiseptics

The use of antiseptics following mechanical therapy is of great importance in preventing bacterial recolonization and supporting the patient's oral hygiene efforts. (Figuero, Graziani, Sanz, Herrera & Sanz, 2014) The most commonly used antiseptics as adjuncts to mechanical debridement include agents such as chlorhexidine (CHX), saline, and hydrogen peroxide (H_2O_2). (Dos Santos Martins, Fernandes, Martins, de Moraes Castilho & de Oliveira Fernandes, 2022)

Chlorhexidine (CHX)

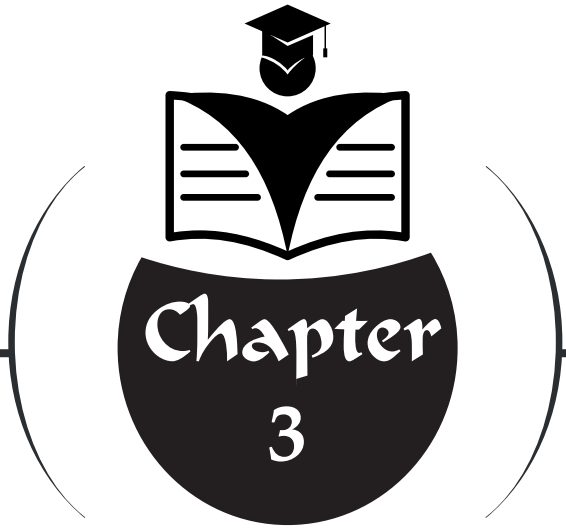
Several studies have reported that the adjunctive use of chlorhexidine with mechanical debridement has limited effects on clinical and microbiological parameters. (Renvert, Roos-Jansåker & Claffey, 2008) However, overall assessments of the literature indicate that the effectiveness of chlorhexidine on peri-implantitis tissues is not statistically significant. Therefore, further comprehensive studies are needed to clearly determine its efficacy in the non-surgical treatment of peri-implantitis. (Ye, Liu, Cheng & Yan, 2023)

Probiotics

Some studies investigating the use of probiotics as an adjunct to mechanical debridement have observed reductions in bleeding on probing and probing depth in patients with peri-implantitis. (Galofré, Palao, Vicario, Nart & Violant, 2018; Tada et al., 2018) On the other hand, other studies have reported no additional benefits from probiotic administration. Hence, further research is required to establish the optimal dosage and administration methods for probiotics in non-surgical treatments. (Linares et al., 2023)

Conclusion

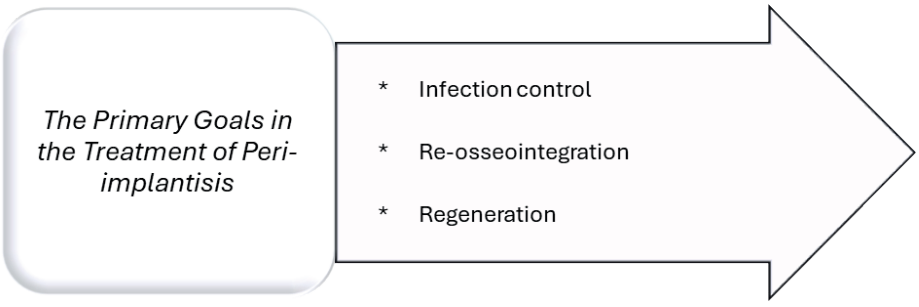
The primary approach in the treatment of peri-implantitis involves infection control, non-surgical debridement, and regenerative or resective surgical techniques. (Polyzois, 2018) Although the effectiveness of non-surgical treatment protocols continues to be investigated, there is still no consensus regarding the most effective therapeutic strategy in this field. (Hentenaar et al., 2021) In cases where healing cannot be achieved despite all interventions, and when surgical treatment is either not preferred or contraindicated, repeated non-surgical therapy remains among the available treatment options. (Wang, Renvert & Wang, 2019)



SURGICAL TREATMENT APPROACHES FOR PERI-IMPLANT DISEASES

Although non-surgical approaches may be effective in certain clinical scenarios for the treatment of peri-implantitis, they are generally insufficient, particularly in advanced stages of the disease. (Renvert & Polyzois, 2018) This inadequacy is attributed to factors such as the facilitation of biofilm accumulation on implant surfaces accompanied by bone loss, the presence of contaminating tissues such as epithelium that are not naturally exfoliated, the challenges in decontaminating rough implant surfaces, and the limited accessibility to these areas. (Renvert, Polyzois & Claffey, 2011) Moreover, the presence of microbial colonization around implants resembling the gram-negative anaerobic flora observed in severe periodontitis cases in natural teeth, and the difficulties in controlling these pathogens, further diminish the efficacy of non-surgical treatment options. (Renvert et al., 2007) Nevertheless, implementing a non-surgical treatment phase prior to surgical intervention is essential to establish a healthier peri-implant soft tissue environment. Following the control of acute infection and the improvement of oral hygiene, surgical treatment modalities may be considered in cases presenting with peri-implant pockets deeper than 5 mm and evident bone loss. (Schou, Berglundh & Lang, 2004)

The primary objectives in the treatment of peri-implantitis include infection control, the re-establishment of osseointegration, and the promotion of bone regeneration. Although preclinical studies have demonstrated bone-to-implant contact, these findings have not yet been sufficiently validated in human studies. (Parlar et al., 2009) While surgical approaches are suggested to enhance treatment efficacy, there remains a need for long-term, human-based clinical studies to support this claim.



Surgical Treatment and Decontamination Protocols

Within the scope of surgical treatment, a variety of methods have been employed, including open flap debridement, regenerative techniques, resective procedures, and combined approaches. Additionally, various decontamination protocols - mechanical, chemical, laser-based, and antimicrobial photodynamic therapies - have been implemented. (Schou, Berglundh & Lang, 2004)

Decontamination Approaches

Regardless of the surgical technique selected, effective decontamination of the implant surface is a critical component for successful peri-implantitis treatment. To this end, several decontamination strategies have been developed based on mechanical, chemical, laser-based, or combined methods.

✓ **Mechanical Decontamination:** This approach involves the physical removal of contaminants from the implant surface using instruments such as titanium or Teflon curettes, ultrasonic scalers with specialized tips, or air-abrasive devices. No significant superiority has been demonstrated between hand instruments and power-driven systems, including glycine powder air polishing, ultrasonic devices, titanium or chitosan brushes. (Schwarz, Schmucker & Becker, 2015) A more invasive technique, implantoplasty, involves the mechanical modification of the rough implant surface using burs and stones under copious irrigation to minimize local heat and contamination. This procedure aims to create a smoother and more polished surface that facilitates improved oral hygiene.

✓ **Chemical Decontamination:** In this method, specific chemical agents are applied directly to the implant surface. Agents such as citric acid, hydrogen peroxide (H_2O_2), chlorhexidine (CHX), and saline have demonstrated comparable efficacy. (Khoury & Buchmann, 2001; Schou, Berglundh & Lang, 2004)

✓ **Laser - Assisted Decontamination:** The clinical effectiveness of laser-assisted decontamination remains inconclusive. Although Er:YAG lasers have shown positive effects on bleeding on probing and clinical attachment levels, no significant advantages have been found when compared to conventional mechanical therapy. (Schwarz et al., 2011) It has been reported that decontamination of titanium plasma-sprayed or sandblasted/acid-etched implant surfaces can be most effectively achieved using gauze soaked in chlorhexidine or saline. (Schou, Berglundh & Lang, 2004) However, based on current clinical, radiographic, and microbiological evidence, there is still no universally accepted standard protocol with proven superiority for implant surface decontamination in surgical treatment. (Khoury et al., 2019)

Surgical Techniques

In the surgical treatment of peri-implantitis, various approaches such as open flap debridement, resective techniques, regenerative strategies, or combinations of these methods may be employed. Non-regenerative surgical approaches - such as access flap surgery and resective techniques - primarily aim to reduce bacterial load, control inflammation, and halt disease

progression. In contrast, regenerative surgical techniques are applied not only to achieve these goals but also to promote re-osseointegration and repair existing bone defects. (Schou, Berglundh & Lang, 2004)

An effective surgical approach should incorporate a systematically planned surgical design, a validated surface decontamination protocol, and controlled infection management. (Schwarz et al., 2022) The combination of an apically positioned flap with a free gingival graft (FGG) is considered one of the most effective treatment modalities, as it contributes to increasing the width of keratinized mucosa, improving bleeding indices and plaque scores, and maintaining marginal bone levels around implants. (Khoury et al., 2019)

When selecting a surgical technique, factors such as defect morphology and regenerative potential, severity of peri-implantitis, the patient's systemic condition, level of oral hygiene, implant surface characteristics, and the patient's esthetic and functional expectations should be carefully considered. According to the literature, variables related to the patient, the implant, and the affected site influence defect morphology, which in turn has a direct impact on the success of surgical reconstruction. (Monje et al., 2019) In a study by Monje et al. investigating the morphology and severity of peri-implantitis-associated bone defects, class I and class III defects were found to be the most frequently encountered, often accompanied by buccal bone loss. Furthermore, smoking and age were identified as influencing factors on defect morphology, while smoking, prosthesis type, and the distance to adjacent implants were reported to significantly affect the severity of vertical bone loss. (Monje et al., 2019)

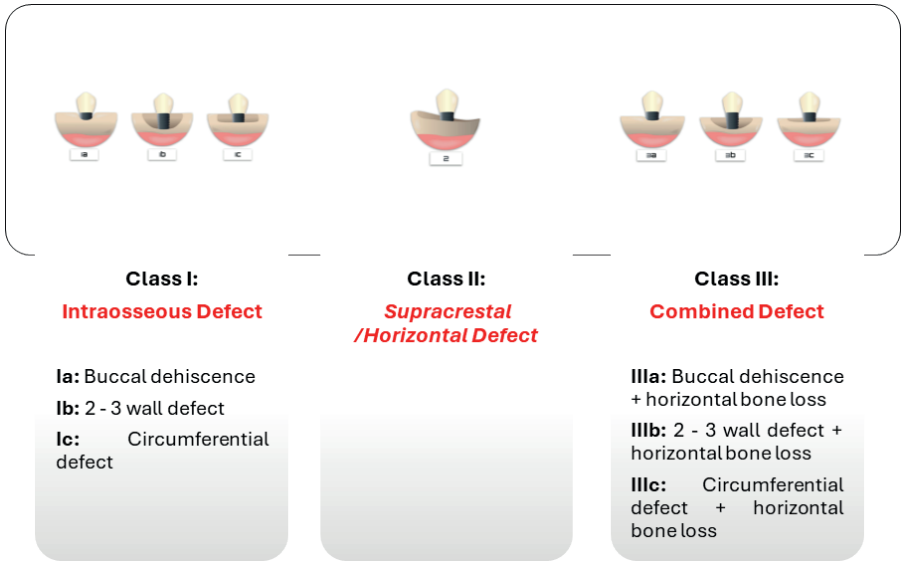


Figure 1. *Morphological defect classification of peri-implantitis (Monje et al., 2019)*

Open Flap Debridement

Open flap debridement, which allows direct decontamination of the implant surface while preserving the surrounding soft tissues, is considered an effective surgical approach particularly in cases with minimal peri-implant bone loss. It has also been reported to be applicable in esthetically sensitive areas when non-surgical interventions fail to achieve satisfactory outcomes.

Surgical Approach

The surgical procedure begins with an intrasulcular incision, followed by elevation of full-thickness mucoperiosteal flaps from both the vestibular and lingual/palatal aspects to expose the implant surface. Granulation tissues are thoroughly removed from the affected area using curettes, and the implant surface is decontaminated with appropriate methods. At the end of the procedure, the flap margins are repositioned without tension and sutured accordingly. This treatment approach has been reported to result in maintenance of the marginal bone level and, in some cases, even slight gains in bone height. However, an average of 1.8 to 1.9 mm of soft tissue recession has been observed during 1- to 5-year follow-up periods. In patients treated solely with open flap debridement and enrolled in a structured supportive care program, 5-year implant survival rates were found to improve, with probing depths <5 mm showing no bleeding on probing, suppuration, or progressive bone loss. (Roos-Jansåker et al., 2011; Hallström et al., 2017; Heitz-Mayfield et al., 2018)

Comparative studies of various decontamination methods have shown no statistically significant difference in clinical outcomes between diode laser (980 nm) and conventional mechanical decontamination using saline-soaked cotton applicators. (Papadopoulos et al., 2015) On the other hand, repeated local application of minocycline has demonstrated favorable clinical and radiographic outcomes during a 6-month follow-up period. (Cha, Lee & Kim, 2019) Systemic antibiotic administration following flap surgery did not result in significant improvements in clinical, radiographic, or microbiological outcomes over a one-year period. (Hallström et al., 2017)

An alternative surgical technique that may be employed during open flap debridement is apically positioned flap (APF). This approach aims to reduce probing depth and improve plaque control. It is typically preferred in non-esthetic zones, suprabony defects, or one-wall intrabony defects. The reverse bevel incision is planned based on pocket depth, mucosal width, and thickness. Vertical releasing incisions may be required to allow apical repositioning of the flap. Depending on the case, osteoplasty may be performed on the bone surface, and implantoplasty may be considered for exposed implant threads.

Regenerative Surgery

Regenerative surgical approaches aim not only to control inflammation but also to achieve re-osseointegration, regenerate the bony defect, and limit soft tissue recession. These procedures are particularly recommended in peri-implantitis cases with three- or four-wall crater-type defects, intrabony defects at least 3 mm in depth, and the presence of keratinized mucosa. (Jepsen et al., 2019)

Surgical Approach

The surgical procedure begins with an intrasulcular incision, followed by elevation of full-thickness mucoperiosteal flaps on the buccal and lingual/palatal aspects. After thorough removal of granulation tissue, the implant surface is decontaminated. The intrabony defect is filled with autogenous or alternative bone graft materials, which may be covered with resorbable or non-resorbable membranes. The flaps are repositioned coronally and sutured using either a one-stage or two-stage technique. Although no definitive clinical superiority has been established between these two approaches, the most recent consensus report by the FDI World Dental Federation recommends the submerged (two-stage) approach to support healing after regenerative surgery. Additionally, the report emphasizes the importance of removing the prosthetic restoration, if feasible, and redesigning it to facilitate optimal oral hygiene. (Khoury et al., 2019)

Comparative studies on decontamination methods have shown, for instance, that ozone application leads to greater bone formation than sterile saline. Moreover, no significant differences have been observed between long-term outcomes of air powder abrasion and CO_2 laser application. To date, there is no strong or conclusive evidence favoring one specific decontamination protocol over others. (Ramanauskaite et al., 2019)

Although membrane use is preferred in certain cases during grafting procedures, autogenous bone grafts are still considered the gold standard. (Khoury et al., 2019) However, fistula or sequestrum formation has been reported in 58.6% of cases where resorbable or non-resorbable membranes were used. (Ramanauskaite et al., 2019) These findings highlight the need for careful clinical decision-making regarding membrane application.

Preclinical studies on animal models have demonstrated histological evidence of defect fill and re-osseointegration using regenerative techniques. (Schwarz et al., 2011; Almohandes et al., 2019) These studies have shown more frequent osseointegration, greater marginal bone gain, and better preservation of soft tissue margins on smooth-surfaced implants compared to moderately rough ones. (Almohandes et al., 2019) Nevertheless, although regenerative

treatment outcomes appear promising for sandblasted/acid-etched implant surfaces, such results have yet to be confirmed for machined-surface implants. (Schou, Berglundh & Lang, 2004) Clinical studies on regenerative surgical approaches have reported significant improvements in both clinical and radiographic parameters, with follow-up periods ranging from 6 months to 7 - 10 years. (Khoury et al., 2019)

Resective Surgery

Resective surgical treatment is preferred in areas with horizontal bone loss, low esthetic risk, and exposed implant threads. In this approach, the flap is apically repositioned, and bone contours are reshaped with or without concomitant implantoplasty to eliminate or reduce the depth of pathological pockets. (Keeve et al., 2019) The reported success rate for this treatment varies between 33% and 75%. (de Waal, Raghoebar, Meijer, Winkel & van Winkelhoff, 2016)

Several factors may negatively impact treatment outcomes, including limited surgical experience, smoking, presence of suppuration before treatment, baseline probing depth > 8 mm, bone loss > 7 mm, inadequate postoperative plaque control, and implant surface morphology. (Carcuac et al., 2017) The presence of residual pockets ≤ 5 mm and absence of bleeding on probing during maintenance visits are associated with a reduced risk of progressive bone loss. (Berglundh, Wennström & Lindhe, 2018) Moreover, the presence of ≥ 4 mm probing depths on three or more implant surfaces significantly increases the risk of clinical attachment loss, similar to findings in natural dentition. (Serino, Turri & Lang, 2015)

Various agents have been used for surface decontamination, including chlorhexidine digluconate, hydrogen peroxide, sterile saline, phosphoric acid, antibiotic gels, and Er:YAG laser. (Romeo et al., 2005; de Waal et al., 2013; Hentenaar et al., 2017; Koldsland, Wohlfahrt & Aass, 2018) The combination of 0.12% chlorhexidine gluconate and 0.05% cetylpyridinium chloride has been shown to significantly reduce the anaerobic bacterial load compared to sterile saline; however, no substantial improvement in clinical parameters was observed. (Carcuac et al., 2016)

Systemic antibiotic administration demonstrated favorable short-term (1-year) clinical outcomes in treated-surface implants (e.g., probing depth ≤ 5 mm, absence of bleeding/suppuration, and ≤ 0.5 mm bone loss), though these effects diminished over a three-year period. (Carcuac et al., 2016)

Recent studies suggest that implant surface topography plays a decisive role in treatment outcomes. Notably, non-modified (machined) implant surfaces demonstrated greater probing depth reductions and a higher prevalence of

residual probing depths ≤ 5 mm during the first three years post-treatment compared to rough surfaces. (Carcuac et al., 2017) Furthermore, long-term (2–10 years) follow-up revealed better maintenance of crestal bone levels in these implants. (Berglundh, Wennström & Lindhe, 2018)

In non-regenerative approaches, implantoplasty has yielded significant improvements in pocket depth and bleeding on probing, and, compared to mechanical debridement alone, has resulted in superior clinical and radiographic outcomes during a 3-year follow-up. (Keeve et al., 2019)

Implantoplasty

Implantoplasty is a procedure aimed at modifying the implant surface into a smooth and polished morphology. This technique is indicated in cases where bone regeneration is not intended, such as suprabony defects or areas with exposed implant threads. Commonly used instruments include diamond burs, Arkansas stones, and silicon polishers. (Romeo, Lops, Chiapasco, Ghisolfi & Vogel, 2007; de Tapia et al., 2019) The application of Arkansas stones following diamond bur instrumentation has been shown to be the most efficient method for achieving the desired surface smoothness while reducing procedure time. (Sharon, Shapira, Wilensky, Abu-Hatoum & Smidt, 2013)

Implantoplasty has been associated with increased implant survival rates and significant reductions in probing depth and bleeding on probing. (Romeo et al., 2005) Additionally, the interproximal bone level remained stable over a 3-year period. However, the procedure has also been linked to increased gingival recession, making it more suitable for non-esthetic zones. (Renvert & Polyzois, 2015)

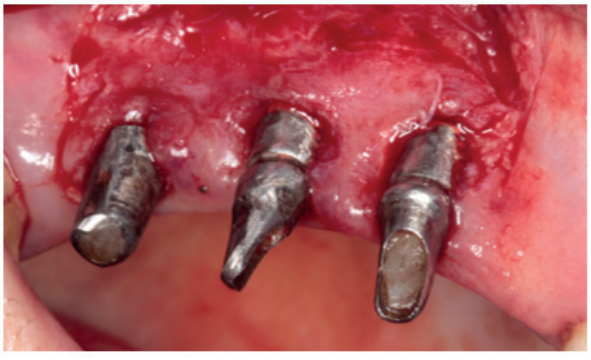


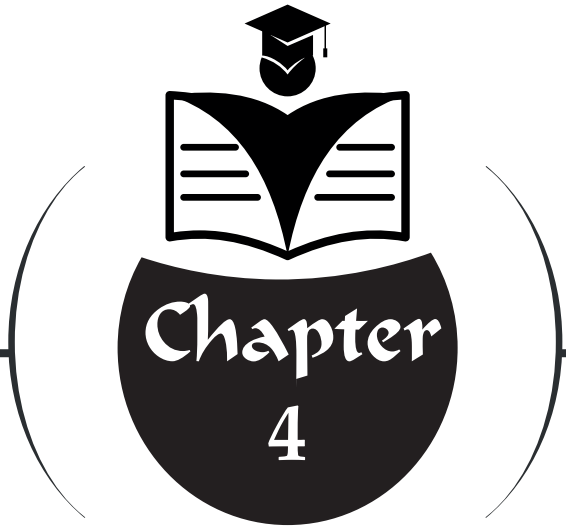
Figure 2. *Implantoplasty*

Following a six-month observation period, implantoplasty was found to be as effective as glycine powder air-polishing. Moreover, after a three-year follow-up,

the marginal bone level changes were reported to be less pronounced compared to cases treated with bone resection alone. (Romeo, Lops, Chiapasco, Ghisolfi & Vogel, 2007; Lasserre, Brecx & Toma, 2020). In cases where implantoplasty was performed concurrently with resection, 89% of implants demonstrated stable marginal bone levels at the three-year mark. (Bianchini et al., 2019) Short- and mid-term outcomes indicate no association between implantoplasty and mechanical or biological complications. However, the potential risks associated with this approach - such as structural weakening due to thinning of the implant body, recession of the peri-implant mucosa, aesthetic concerns especially in the anterior region, and accumulation of titanium particles in the soft tissue - necessitate careful case selection and clinical judgment. (Augthun, Tinschert & Huber, 1998; Stavropoulos, Bertl, Eren & Gotfredsen, 2019)

Combined Surgical Approach

One of the surgical options in the treatment of peri-implantitis is the combination of regenerative and resective techniques. In this approach, the intrabony component of the defect is treated using regenerative techniques, while the suprabony part is managed with resective procedures. The use of titanium rotary brushes for decontamination has shown greater reduction in probing depth and defect fill compared to plastic ultrasonic curettes and 3% hydrogen peroxide (H_2O_2) application. (de Tapia et al., 2019) In long-term follow-up studies (6 - 10 years), peri-implantitis resolution was reported in 28% of patients treated with combined surgical approaches. (Ramanauskaite, Becker, Juodzbalys & Schwarz, 2018) In a 7-year clinical study, treatment success, defined by the absence of bleeding on probing, was reported to be 60%. (Schwarz, John, Schmucker, Sahm & Becker, 2017) Other studies with five- and seven-year follow-up periods reported treatment success rates of 35% based on the absence of bleeding/suppuration, probing depth less than 5 mm, and no further bone loss; and 51.1% when success was defined as probing depth <5 mm, bone fill >25%, and bleeding score <1. (Roos-Jansåker et al., 2014; Roccuzzo et al., 2017) Nevertheless, the variability in success criteria among studies complicates the comparison of clinical outcomes. Additionally, previous bone grafting procedures at the implant site were found not to significantly influence the effectiveness of combined surgical treatment. (Ramanauskaite et al., 2018) Post-surgical supportive periodontal therapy plays a critical role in improving implant survival rates - ranging from 76% to 100% over 5 years and 70% to 99% over 7 years - and in maintaining bone level stability. (Roccuzzo, Layton, Roccuzzo & Heitz-Mayfield, 2018) Supportive care intervals should be individualized and scheduled every 3 to 6 months based on patient-specific risk factors and clinical requirements. (Heitz-Mayfield et al., 2018)



THE TUNNEL TECHNİQUE IN THE TREATMENT OF GINGIVAL RECESSION

Gingival recession is defined as the apical migration of the gingival margin beyond the cemento-enamel junction, resulting in the exposure of the root surface. (Wennström, 1996; Armitage, 1999) This condition not only raises aesthetic concerns but also leads to various clinical problems, such as dentin hypersensitivity, an increased risk of root surface caries, and difficulty in maintaining effective plaque control. (Lovegrove & Leichter, 2004)

Numerous predisposing factors contribute to the etiology of gingival recession. These factors include: (Tugnait & Clerehugh, 2001)

- ✓ Anatomical characteristics of the individual
- ✓ The position of the teeth within the dental arch
- ✓ A history of orthodontic treatment
- ✓ Traumatic or improper tooth brushing habits
- ✓ Inadequate keratinized tissue
- ✓ Mechanical trauma induced by prostheses
- ✓ Malocclusion

The concept of mucogingival surgery refers to surgical procedures aimed at correcting aesthetic and functional problems associated with the soft tissues surrounding teeth or dental implants. (Zucchelli & Mounssif, 2015) The term was first introduced by Friedman in 1957 and was initially used for procedures such as deepening the vestibule and eliminating frenulum attachments. Over time, more advanced soft tissue surgical techniques have been developed, particularly for the coverage of exposed root surfaces. Among these, free gingival grafts (FGG), connective tissue grafts (CTG), and pedicle flap techniques have become widely adopted in clinical practice. (Needleman, Moles, & Worthington, 2005)

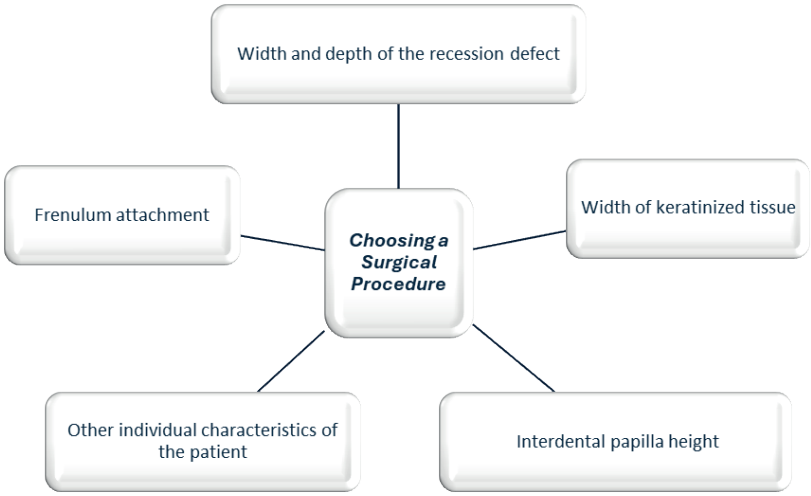


Figure 1. *Factors to be considered in the selection of surgical procedures (Zucchelli & De Sanctis, 2000)*

Classification of Gingival Recessions

Gingival recessions are classified in various ways based on their clinical characteristics. Among these, one of the most widely used systems is the classification proposed by Miller. The Miller classification categorizes recession defects into four distinct classes, based on the extent of hard and soft tissue involvement. (Figure 2) In this system, the presence of periodontal tissue loss in adjacent interproximal areas and whether the recession extends beyond the mucogingival junction are considered the primary criteria. (Miller, 1985) However, this classification has certain limitations, particularly in differentiating cases where interproximal attachment loss is absent or minimal.

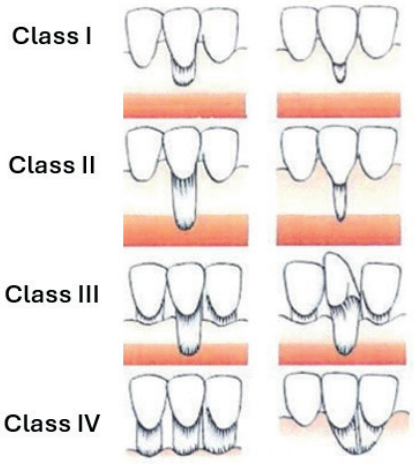


Figure 2. *Miller's classification of gingival recession (Miller, 1985)*

The updated classification system developed by Cairo et al. offers a more objective and reproducible method for evaluating gingival recessions by relying on the level of interproximal clinical attachment. (Cairo, Nieri, Cincinelli, Mervelt, & Pagliaro, 2011) (Table 1) This classification is particularly valuable in surgical procedures aimed at root coverage, as it facilitates more predictable treatment planning.

Cairo Type 1	·	Interproximal attachment loss --
Cairo Type 2	·	Interproximal attachment loss ≤ Mid-facial loss
Cairo Type 3	·	Interproximal attachment loss > Mid-facial loss

Table 1. *New classification system as proposed by Cairo et al. (2011)*

The Emergence and Evolution of Tunnel Techniques

Traditional flap techniques used in the treatment of gingival recessions often involve the separation of papillary tissues and extensive manipulation of the keratinized gingiva. Although these approaches may yield clinically successful outcomes, they also present certain limitations, such as disruption of tissue integrity, suboptimal aesthetic results, and postoperative discomfort. These challenges have prompted researchers to develop more conservative and minimally invasive approaches. Raetzke (1985) introduced the "envelope flap" technique, which involved no releasing incisions and preserved the integrity of the papillary structures while being applied to a single tooth. Subsequent advancements in grafting techniques and suture materials enabled modifications of this method for use in multiple adjacent recessions. Allen (1994) refined the approach by creating a supraperiosteal envelope flap of partial thickness and enlarging the recipient site for the placement of a connective tissue graft. This modification allowed for the simultaneous treatment of multiple recession defects. Zabalegui et al. (1999) were the first to describe this approach in the literature as the "tunnel technique," forming a tunnel in the buccal mucosa through interconnected envelope flaps. Later, Zuhr et al. (2007) redesigned the technique based on microsurgical principles, introducing the modified microsurgical tunnel approach, which utilized specially designed surgical instruments and advanced suturing techniques. The main objective of this refined version was to reduce surgical trauma while improving graft stability and flap management.

More recently, various modifications of the tunnel technique have been introduced into the literature. Tözüm and Dini (2003) reported that initiating the tunnel flap with partial-thickness dissection mesially, distally, and beneath the papillae, and then converting to full-thickness at the mucogingival junction, could enhance vascular support. This approach was noted to have potential in reducing postoperative complications and promoting favorable tissue healing. To further improve the technique's applicability, alternative approaches have been developed for different anatomical regions. Zadeh (2011) proposed the preparation of a subperiosteal tunnel through a vertical vestibular incision to facilitate easier access in the maxillary anterior region. This technique aimed to minimize surgical trauma while enhancing aesthetic outcomes.

Since its initial development, the tunnel technique has undergone numerous modifications in both surgical design and the use of adjunctive materials. (Aroca et al., 2010; Sculean et al., 2014) As a result, various customized tunnel techniques have emerged, tailored to specific clinical indications.

Advantages and Limitations of Tunnel Techniques

Tunnel techniques are minimally invasive procedures developed to address increasing aesthetic demands and to promote more conservative approaches in soft tissue surgery. Compared to traditional flap surgeries, these techniques offer several advantages from both aesthetic and biological perspectives. However, as with any surgical approach, tunnel techniques also present certain limitations. (Zuhr, Rebele, Cheung, & Hürzeler, 2018)

Advantages	· Vascularization is preserved due to the maintenance of papillary integrity, thereby increasing the survival rate of the graft.
	· Scar formation in the aesthetic zone is prevented, resulting in a more natural appearance.
	· Postoperative complications such as swelling, bruising, and pain are less frequently observed.
	· Controlled flap mobilization enhances graft stability.
	· Patient satisfaction is notably higher, especially in the anterior regions.
Disadvantages and Limitations	· The technique's precision and the surgeon's experience directly influence the outcomes.
	· Proper placement of the graft and passive closure of the flap can be challenging.
	· The requirement for instruments and equipment is greater compared to conventional methods.
	· Creating a tunnel in thin biotype and very narrow tissues can be technically challenging and carries inherent risks.
	· There is a risk of injury to the papillae during tunnel extension, which may adversely affect the aesthetic outcome.

Contemporary and Commonly Applied Tunnel Techniques

Laterally Positioned Tunnel Technique

The laterally positioned tunnel technique, described by Sculean and Allen, is a minimally invasive surgical approach developed specifically for the treatment of isolated, deep, and narrow gingival recessions. Due to its tissue-preserving nature and its ability to meet high aesthetic demands, this technique has seen increasing clinical application in recent years. (Sculean & Allen, 2018)

Surgical Approach

The procedure begins under local anesthesia with root surface debridement using gracey curettes. This is followed by the creation of sloped intrasulcular incisions using microsurgical blades. A tunnel is then formed in the mucoperiosteal plane with the aid of specially designed tunnel

instruments. During this phase, epithelial tissue is naturally removed as part of the incision process, making additional epithelial excision unnecessary.

The tunnel is extended apically beyond the mucogingival junction and advanced mesially and distally beneath the interdental papillae, along the margins of the recession defect. Maintaining the integrity of the papillary structures and the continuity of the flap is crucial during the procedure. A connective tissue graft (CTG), prepared to the appropriate dimensions, is inserted into the tunnel. The flap margins are then advanced coronally over the graft without tension, covering the exposed root surface, and secured in place using sutures. (Figure 3) (Sculean & Allen, 2018)

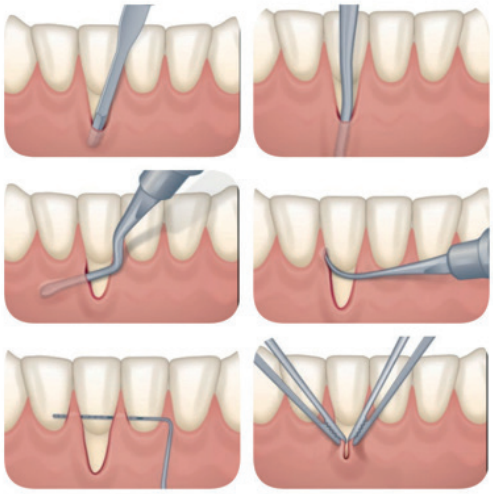


***Figure 3**. Stages of tunnel preparation in the surgical site (Sculean & Allen, 2018)*

In a case series applying this technique, complete root coverage was achieved in approximately 70% to 75% of cases, depending on the type of recession defect. This approach has been shown to provide a clinically predictable and effective alternative for the treatment of isolated Miller Class I, II, and III gingival recessions, particularly in the mandibular region. (Sculean & Allen, 2018)

Coronally Advanced Flap (CAF) and Tunnel Surgery

Among the most commonly employed surgical techniques for the treatment of gingival recessions are the coronally advanced flap (CAF) and the tunnel technique. These two approaches are often considered alternatives to one another, and in clinical practice, typically only one is selected for root

coverage procedures. Contrary to this conventional dichotomy, a novel surgical approach that combines the advantages of both techniques was proposed in 2022. (Figure 4) (Barootchi & Tavelli, 2022) In a study conducted by Barootchi and Tavelli, this combined technique was applied in 10 patients presenting with isolated Cairo Type 2 recession defects. The surgical protocol integrated the tunnel approach with a coronally advanced flap and a subepithelial connective tissue graft (SCTG). At the six-month follow-up, a mean root coverage of 86.5% was achieved, with complete root coverage obtained in six out of ten sites.

These findings suggest that the combined technique represents an effective and predictable treatment option, particularly in cases of isolated buccal recessions with minimal interproximal attachment loss. Moreover, this approach appears to enhance flap vascularization, thereby supporting graft nourishment, and has the potential to improve aesthetic, clinical, and patient-centered outcomes, especially in situations where papillary height is inadequate. However, the authors emphasize the need for larger-scale randomized controlled trials to evaluate the generalizability of these outcomes. (Barootchi & Tavelli, 2022)

Figure 4. *Stages of the coronally positioned flap and tunnel technique (Barootchi & Tavelli, 2022)*

Vestibular Incision Subperiosteal Tunnel Access (VISTA)

Gingival recessions in the maxillary anterior region can lead to both aesthetic concerns and functional impairments. While the subepithelial

connective tissue graft (SCTG) has traditionally been the preferred treatment for such defects, limitations such as the need for a donor site, restricted graft availability, and morbidity during the healing process may constrain its use. The Vestibular Incision Subperiosteal Tunnel Access (VISTA) technique, developed in recent years, is a minimally invasive surgical method proposed to overcome these limitations. This technique has gained attention due to its ability to provide more controlled flap movement and reduced surgical trauma when treating soft tissue defects in aesthetic zones. (Zadeh, 2011)

Surgical Approach

In the VISTA technique, a single vestibular incision is made at the level of the maxillary frenulum to create a tunnel in the subperiosteal plane. Through this tunnel, root surfaces and any possible bony dehiscences are exposed. The tunnel is extended beyond the targeted teeth, allowing the gingiva to be coronally repositioned under minimal tension. (Figure 5) This approach facilitates more effective flap mobilization in the aesthetic zone and enables more stable placement of graft materials. (Zadeh, 2011)

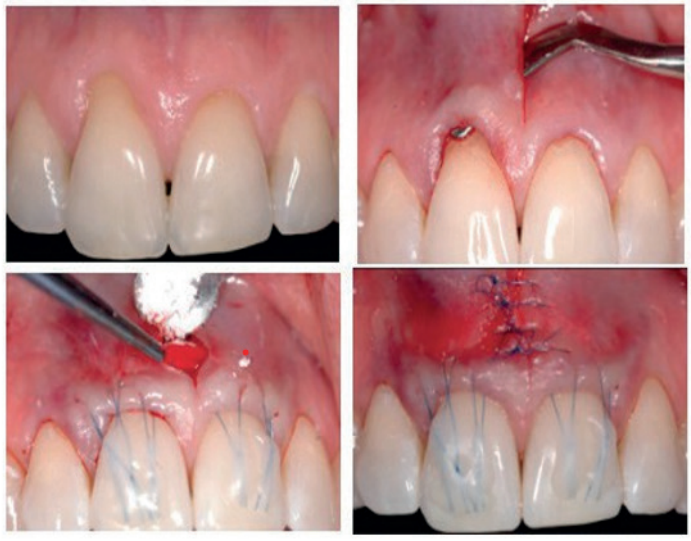


Figure 5. *Stages of the VISTA technique (Zadeh, 2011)*

Modified Vestibular Incision Subperiosteal Tunnel Access (m-VISTA)

In the maxillary anterior region with implant-supported restorations, both the horizontal and vertical dimensions of the soft tissue play a crucial role in determining aesthetic success. In a case reported by Lee et al., the classical VISTA

technique was modified to manage a patient presenting with both horizontal and vertical soft tissue deficiencies around a single implant-supported restoration in the anterior maxilla. (Lee, Hamalian, & Schulze-Späte, 2015)

Surgical Approach

Unlike the classical VISTA procedure, this modification involves preparing a tunnel in the supraperiosteal plane rather than raising a full-thickness flap. The subepithelial connective tissue graft (SCTG) is inserted beneath the peri-implant soft tissue through a single vestibular incision made at the level of the vestibular frenulum. This minimally invasive modification results in significant increases in both soft tissue thickness and height. The modified VISTA technique has demonstrated clinical potential for soft tissue augmentation around implant-supported restorations. (Lee et al., 2015)

Double Vestibular Incision Subperiosteal Tunnel Technique (Double VISTA)

Gingival recessions are complex clinical conditions resulting from the interplay of various anatomical, biomechanical, and behavioral predisposing and accelerating factors. Frequently accompanied by non-carious cervical lesions, these defects require special attention during restorative and periodontal treatment. Traditional surgical approaches often prove inadequate in cases involving multiple adjacent teeth with such complicated lesions due to limited access and insufficient tissue management. (Grippo, Simring, & Schreiner, 2004; Lin, 2025)

The Double VISTA procedure is a variation of the classical single-incision VISTA technique that expands the surgical field by employing two vestibular incisions. This modification enhances the maneuverability of surgical instruments and allows for more controlled placement of graft materials within the tunnel. (Lin, 2025)

Modified Coronally Advanced Tunnel Technique

Managing multiple adjacent gingival recessions, especially in cases with high aesthetic demands, remains one of the most challenging surgical scenarios. These challenges arise from factors such as the depth and width of recessions, insufficient vestibular depth, limited vascularization, and anatomical or biomechanical influences such as frenulum and muscle pull. (Hofmänner et al., 2012; Graziani et al., 2014) These factors complicate flap mobilization and may negatively affect surgical outcomes.

The modified coronally advanced tunnel technique has emerged as a promising method for treating multiple recession defects. This technique avoids vertical incisions and preserves the papillary tissues, thereby maintaining vascular structures and increasing graft survival. (Azzi & Etienne, 1998; Zuhr et al., 2007; Aroca et al., 2010)

Surgical Approach

The procedure begins under local anesthesia with meticulous root surface planing. Subsequently, intrasulcular incisions are performed using microsurgical instruments, and a full-thickness tunnel flap extending beyond the mucogingival junction is prepared. The tunnel is carefully extended mesially and distally beneath adjacent papillae, connecting the recession defects. The flap is then coronally advanced together with a suitable graft material and stabilized with suspension sutures. (Figure 6)

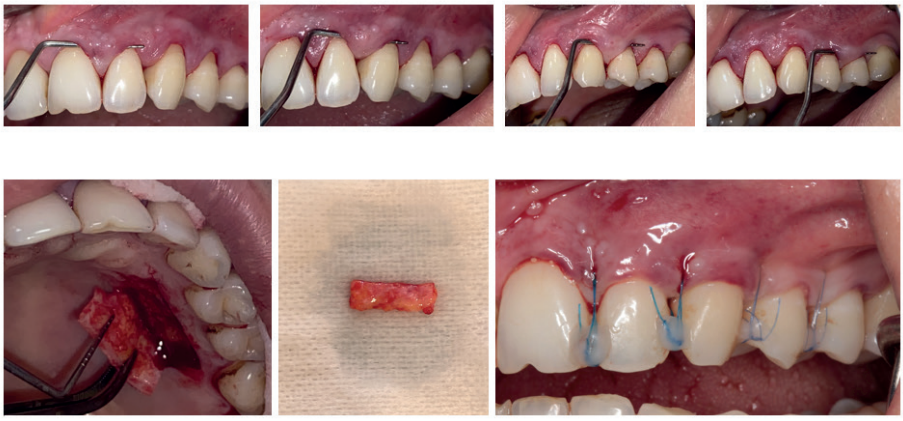


Figure 6. *Stages of the modified coronally advanced tunnel technique.*

Clinical Outcomes of the Modified Coronally Advanced Tunnel Technique

In a study conducted by Stähli et al., the application of the modified coronally advanced tunnel technique combined with a free connective tissue graft (FCTG) demonstrated successful clinical outcomes in both single and multiple Miller Class I, II, and III gingival recessions. Similarly, other studies in the literature have reported that this technique, when combined with FCTG or alternative soft tissue grafts, provides predictable and favorable results for the respective types of recession defects. In cases with insufficient vestibular depth, two-stage treatment protocols combining vestibuloplasty have been suggested to enhance surgical success. (Gaikwad, Lele, Dodwad, & Mariam, 2023)

Overall, the existing evidence supports that the modified coronally advanced tunnel technique combined with various soft tissue grafts constitutes an effective therapeutic alternative for both single and multiple recession cases. (Gaikwad et al., 2023)

Use of Biomaterials

To enhance the efficacy of tunnel techniques and improve long-term success rates, the use of various biomaterial combinations has been proposed. The free connective tissue graft (FCTG), regarded as the gold standard (Figure 7), offers significant advantages in achieving increased tissue thickness and long-term stability. (Chambrone & Tatakis, 2015) However, donor site morbidity, limited graft volume, and patient comfort issues have prompted the development of alternative materials. In this context, biomaterials such as enamel matrix derivatives, acellular dermal matrices, and autologous blood products (e.g., platelet-rich fibrin [PRF], concentrated growth factors [CGF]) have emerged as promising options in the literatüre. (Tözüm & Demiralp, 2003; Ayub et al., 2014; Miron et al., 2016)

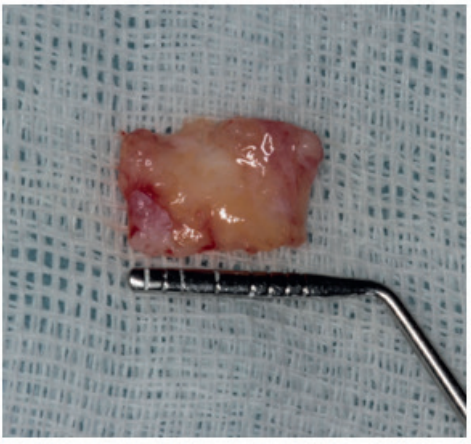


Figure 7. *Subepithelial Connective Tissue Graft (SCTG)*

Conclusion

Minimally invasive surgical approaches represent a significant milestone in the advancement of periodontal plastic surgery procedures. Tunnel techniques, which preserve tissue integrity, support vascularization, and meet increasing aesthetic demands, have emerged as a robust treatment alternative, particularly favored in regions with high aesthetic importance. The evolution

of these techniques has expanded their application from single-tooth to multiple-tooth recession coverage, and from traditional flap methods to those combined with biomaterials. Current literature evidence indicates that modified tunnel techniques, when used in conjunction with connective tissue grafts, enamel matrix proteins, and other bioactive agents, provide successful and predictable outcomes in both aesthetic and functional terms. However, factors such as meticulous case selection, adequate flap mobility, and the surgeon's technical expertise continue to play a decisive role in treatment success. Future randomized controlled trials, long-term follow-up data, and patient-centered evaluations are warranted to comprehensively demonstrate the clinical efficacy of tunnel techniques, thereby further strengthening the role of these minimally invasive approaches in periodontal plastic surgery practice.

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