

**Microsurgical soft tissue enhancement during implant placement
and uncover: comparative evaluation of minimally invasive flap
techniques**

PhD Thesis

by

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RELATED PUBLICATIONS

Shakibaie B, Nava P, Calatrava J, Blatz MB, Nagy K, Sabri H. Impact of Two Implant-Abutment Connection Types on Crestal Bone Stability: A 3-Year Comparative Split-Mouth Clinical Trial. *Int J Periodontics Restorative Dent*. 2024;0(0):1-22.

Shakibaie B, Blatz MB, Conejo J, Abdulqader H. From Minimally Invasive Tooth Extraction to Final Chairside Fabricated Restoration: A Microscopically and Digitally Driven Full Workflow for Single-Implant Treatment. *Compend Contin Educ Dent*. 2023;44(10):582-8.

Shakibaie B, Sabri H, Abdulqader H, Joit HJ, Blatz MB. Peri-implant soft tissue volume changes after microsurgical envelope technique with a connective tissue graft. A 5-year retrospective case series. *Int J Esthet Dent*. 2024;19(2):126-38.

Shakibaie B. Uses of the operating microscope in minimally invasive implantology. *Quintessenz*. 2010;61:293-308.

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ABBREVIATIONS

CAD/CAM	Computer-Aided Design / Computer-Aided Manufacturing
CBCT	Cone Beam Computed Tomography
CHX	Chlorhexidine
CTG	Connective Tissue Graft
DDMF	Double Door Mucoperiosteal Flap
GTR	Guided Tissue Regeneration
HS	Holding Suture technique
KMW	Keratinized Mucosal Width
KPIM	Keratinized Peri-Implant Mucosa
MT	Mucosal Thickness
PRF	Platelet-Rich Fibrin
PROM	Patient-Reported Outcome Measure
PSTD	Peri-implant Soft Tissue Dehiscence
RC	Reduced Collar (implant design feature)
RIE	Roll-in Envelope flap
UNC-15	University of North Carolina 15-mm periodontal probe
VSRF	Vestibular Split Rolling Flap

I. INTRODUCTION

1.1. Background and Rationale

Successful implant therapy relies not only on osseointegration and bone-level stability but also on the integrity of the surrounding soft tissues. The peri-implant mucosa plays a key role in the long-term biological stability, function, and esthetic success of implant therapy. In particular, the presence of an adequate band of keratinized mucosa has been associated with improved clinical outcomes, including reduced plaque accumulation, lower levels of mucosal inflammation, enhanced patient comfort, and improved maintenance of peri-implant health (1, 2).

Histologically, healthy peri-implant mucosa is typically 3 to 4 mm in height and consists of approximately 2 mm of epithelial tissue in contact with the implant surface. This tissue complex comprises connective tissue covered by either keratinized or non-keratinized epithelium, and inflammatory cells may be present even under clinically healthy conditions (3). Notably, a minimum width of keratinized peri-implant mucosa (KPIM) appears to contribute to mucosal stability and a more effective barrier against mechanical and microbial challenges. The absence of adequate KPIM has been shown to increase the risk of peri-implantitis significantly, with odds ratios ranging from 2.78 to 3.68 in recent meta-analyses (1, 2).

Furthermore, reduced KPIM is associated with increased soft tissue recession, peri-implant inflammation, patient-reported discomfort, and bone loss (1, 4). In clinical practice, soft tissue augmentation procedures—most commonly autogenous grafts, though xenogeneic substitutes have also been proposed—are frequently performed to compensate for insufficient KPIM and to improve long-term outcomes (2).

From a preventive perspective, peri-implant mucositis—an inflammatory condition without radiographic bone loss—is primarily induced by bacterial biofilm and is reversible with professional and personal plaque control (5, 6). Nevertheless, a lack of KPIM is considered a modifying risk factor for both mucositis and peri-implantitis, although the literature remains divided regarding the exact width of KPIM required for long-term disease prevention (1, 7, 8). Regular maintenance and mechanical debridement continue to be essential components of disease prevention strategies (9-11).

In addition to its protective function, peri-implant mucosa contributes significantly to esthetic outcomes. A thick mucosal biotype is positively correlated with improved esthetic integration and long-term stability of the soft tissue margin (12, 13). Conversely, deficiencies in mucosal thickness

or contour can lead to compromised esthetics and increased susceptibility to inflammation and recession (12, 14).

Taken together, the current evidence underscores the importance of maintaining adequate peri-implant mucosa, particularly keratinized tissue, as a key determinant of peri-implant health, patient satisfaction, and the esthetic and functional longevity of implant-supported restorations. In particular, both keratinized mucosal width (KMW) and mucosal thickness (MT) have emerged as predictors of peri-implant health, influencing susceptibility to inflammation, soft tissue recession, and esthetic compromise in the visible zone of the smile line (15-24). A recent international expert consensus has provided site-specific surgical recommendations for peri-implant keratinized mucosa augmentation, reinforcing its role in long-term implant health and guiding clinical decision-making across varying anatomical scenarios (25).

Although osseointegration has reached a high degree of predictability with modern implant protocols, the behavior of the peri-implant soft tissues remains more variable and harder to control, especially in the early stages of healing or in thin biotypes (17, 26-29). Dehiscence, soft tissue collapse, and marginal tissue instability are not uncommon, particularly in cases lacking adequate soft tissue volume from the outset (29-31).

Traditionally, these deficiencies have been managed through autogenous soft tissue grafting, most commonly using connective tissue grafts (CTG) harvested from the palate. While effective in augmenting soft tissue thickness and modifying the phenotype, these grafts are associated with considerable drawbacks, including increased patient morbidity, prolonged surgical time, the need for a secondary surgical site, and variability in healing outcomes (23, 29, 32-35).

Other approaches—including xenogeneic collagen matrices, soft tissue substitutes, and allografts—have been explored as alternatives to CTGs, yet they often suffer from limited long-term evidence, unpredictable volume stability, and a risk of delayed healing or inflammatory response (36-41).

As such, their use is often contraindicated in patients with anatomical limitations, systemic conditions, or strong preferences against invasive procedures. In response to these limitations, a clinical need has emerged for minimally invasive approaches that enable soft tissue enhancement without harvesting, while maintaining long-term stability and patient comfort.

Recent studies have explored methods to manipulate the native peri-implant mucosa—rather than introducing additional graft material—as a means of achieving similar volumetric and esthetic benefits (31, 35, 42-45). Microsurgical protocols, supported by enhanced visualization under

operating microscopes, allow for greater precision and tissue preservation during flap manipulation, making such techniques more viable than in the past (46-51).

The biological basis for this approach lies in preserving and optimizing the peri-implant phenotype through tension-free flap design, atraumatic tissue handling, and maximized vascular integrity—principles that have been shown to enhance both healing and long-term soft tissue stability (50, 52-54). These principles are especially relevant in posterior regions, where soft tissue quantity often determines access for hygiene, prosthetic contour, and mucosal sealing (38, 55).

This thesis builds upon this evolving paradigm, in which peri-implant soft tissue phenotype is optimized through autogenous, graftless, and flap-based surgical techniques, performed with microsurgical precision. The following sections will review the current state of soft tissue augmentation in implant dentistry and introduce the specific techniques under investigation.

1.2. Current Concepts in Soft Tissue Augmentation

The augmentation of peri-implant soft tissues has become an established aspect of comprehensive implant therapy, especially in esthetically sensitive zones or in patients with thin mucosal phenotypes. Numerous approaches have been developed to increase keratinized tissue width and soft tissue thickness, including free gingival grafts, connective tissue grafts (CTGs), xenogeneic collagen matrices, and a wide array of biomaterial substitutes (29, 32, 36, 40, 41). While CTGs remain the gold standard due to their predictability in increasing soft tissue volume and long-term outcomes, their use is inherently invasive and associated with higher patient morbidity (32-35, 37, 56).

In recent years, the clinical conversation has shifted toward identifying graftless alternatives that provide equivalent soft tissue benefits without the need for palatal harvesting or foreign biomaterials. Autogenous, site-specific techniques that utilize and reposition local mucosa have gained traction, especially when supported by microsurgical protocols that improve handling and precision (31, 35, 42-45, 48-51).

These developments are underpinned by two core ideas: first, that thickened peri-implant mucosa contributes to improved marginal bone levels, better esthetic integration, and resistance to mechanical and microbial trauma; and second, that surgical trauma itself—especially when extensive—can compromise healing and esthetic outcomes, particularly in cases with thin tissue biotypes or compromised healing potential (15-21, 23, 29, 34, 45, 50).

Several investigations have confirmed that graftless soft tissue techniques—such as rolled or pedicled flaps—achieve comparable clinical outcomes in specific indications while improving

patient satisfaction and reducing complication risk (22, 29, 32, 35, 55). Additionally, the use of microsurgical instruments and magnification has been associated with improved vascular preservation, reduced edema, and enhanced wound healing due to lower tissue trauma (46-51, 57).

In this context, the evolution of autogenous pedicle flaps, split-thickness rolling flaps, and tunneled flap techniques represents a significant advancement. These methods are designed to repurpose and preserve native mucosa, leveraging soft tissue elasticity and controlled repositioning rather than adding foreign tissue or materials (43, 53, 55, 58-60). This concept also draws from broader clinical principles such as papilla preservation and tension-free closure, which have long been recognized as keys to maintaining esthetic integrity and minimizing complications (50, 53, 54, 61).

As such, these techniques align with broader trends in implant surgery favoring minimally invasive, patient-centered, and highly precise protocols, especially when combined with digital planning, guided surgery, and CAD/CAM restorative workflows (47, 48, 62). Their integration into standard care reflects a new generation of flap design and tissue management strategies suited to the esthetic and functional demands of modern implant therapy.

1.3. Rolling and Envelope-Based Flap Techniques

The concept of soft tissue “rolling” as a strategy for volume augmentation was first introduced in the 1980s with the classic roll flap technique developed for ridge contour enhancement in edentulous sites (58). Since then, the method has undergone various modifications to adapt to different clinical objectives and anatomical settings, including the modified roll, pouch roll, and omega roll techniques (43, 53, 55). These approaches share a common biomechanical rationale: to create a buccal volume enhancement by folding or rolling native tissue upon itself, thereby avoiding graft harvesting and preserving blood supply.

The rolling flap strategy is particularly attractive in implant dentistry, where buccal tissue deficiencies can compromise the esthetic emergence profile and increase the risk of peri-implant dehiscence. By repositioning well-vascularized, native tissue into a prepared envelope or tunnel, clinicians can achieve three-dimensional soft tissue augmentation without the need for palatal grafts or collagen substitutes (35, 38, 43, 60).

Over time, rolling flap concepts have been refined through both anatomical insight and technical innovation. In posterior implant zones, for example, adaptations such as the “micro-roll” and “split-roll” have been used to deliver smaller-volume enhancements without overbulking or compromising hygiene (38, 55, 59). Meanwhile, in anterior sites, envelope-based approaches have

been shown to support papillae and emergence profile development while maintaining mucosal symmetry (27, 53, 63).

A key refinement of these techniques has been the incorporation of split-thickness dissection and tunneling principles, which allow the flap to be partially separated and mobilized without fully detaching it from its pedicle. This maintains vascular supply while increasing the adaptability of the tissue for controlled repositioning (44, 55). When combined with crestal or vestibular de-epithelialization, the rolled flap can be securely packed into a buccal tunnel or pouch, resulting in enhanced mucosal thickness and improved ridge contour (38, 43, 53, 55, 58-60).

Several variations of these envelope or tunnel techniques have also been reported in conjunction with other augmentation strategies—such as simultaneous guided bone regeneration (GBR), connective tissue grafts, or collagen matrices—although their combined use can increase surgical complexity and cost (36, 37, 52, 58, 63, 64).

However, rolling techniques introduce a new set of technical challenges. Stabilizing the rolled tissue, especially during implant placement or exposure, requires precise control over incision design, tissue tension, and suture positioning. In conventional surgery, this has often led to variability in outcomes. The introduction of magnification-assisted microsurgery, however, has addressed many of these limitations by enabling finer, more controlled dissection and manipulation of delicate soft tissues (47-49, 51, 57).

At present, rolling flap concepts have evolved from generalized soft tissue augmentation tools into stage-specific, technique-driven procedures that are integrated into implant placement and uncovering protocols. These modern adaptations are particularly well-suited to clinical scenarios where baseline tissue volume is sufficient, but strategic thickening or reshaping is necessary to optimize esthetics, hygiene, or long-term stability (35, 38, 42, 44, 63).

This thesis investigates two such advanced rolling-based techniques: the roll-in envelope flap (RIE) and the vestibular split rolling flap (VSRF), applied at implant placement and second-stage surgery, respectively.

1.4. The Roll-In Envelope Flap in Implant Placement

The Roll-In Envelope (RIE) flap represents a refinement of the traditional roll technique, designed specifically for use during implant placement in posterior regions with sufficient baseline tissue volume. This technique builds upon the principle of preserving and repurposing autogenous mucosa by rolling it into a buccal envelope, rather than harvesting a separate graft. The RIE approach integrates elements of partial-thickness dissection, crestal de-epithelialization, and

microsurgical rolling, all performed under enhanced magnification for improved precision and vascular control (35, 38, 43, 46, 53, 55, 58, 59).

At its core, the RIE technique involves outlining a split-thickness mucosal flap through carefully placed bucco-lingual and mesiodistal incisions, extending slightly beyond the planned implant site. After de-epithelializing the crestal soft tissue, the flap is rolled inward toward the buccal side, creating a submucosal cushion that thickens the peri-implant vestibular soft tissue. This maneuver improves MT and enhances buccal contour at the time of implant insertion—all without the introduction of foreign material or the need for a palatal donor site (35, 53, 58).

Previous envelope-based flap designs were often developed for use in edentulous ridges or during prosthetic emergence contouring, but the RIE method applies similar mechanics in a way that is compatible with immediate or delayed implant placement, offering improved surgical integration (55, 65). In particular, its design makes it suitable for posterior implants where the buccal aspect is thin or at risk of recession. The concept also aligns with broader approaches to mucosal preservation and augmentation in implant site development (27, 66, 67).

An essential technical consideration in the RIE approach is flap stabilization. Unlike traditional rolling methods, which often rely on tissue compression alone or broad sutures, the RIE flap is anchored in place using precisely positioned vertical mattress sutures, placed under the guidance of an operating microscope. These sutures pass through the rolled flap and into the crestal mucosa, ensuring secure positioning and compression throughout healing (35, 43).

Additionally, previous roll or pouch designs often relied on macrosurgical techniques, which may have introduced variability in flap thickness or vascular supply. Microsurgical visualization and instrumentation, as used in the RIE protocol, reduces such variability and promotes tension-free wound closure—factors known to influence the stability of peri-implant tissues (46-48, 57).

The RIE flap offers a solution to several clinical concerns: it enables minimally invasive augmentation in cases where CTGs would otherwise be indicated; it avoids the morbidity of palatal harvesting; and it supports soft tissue thickening without delaying implant placement or requiring additional surgical steps. This approach is particularly well suited to patients with adequate crestal and vestibular bone volume but a thin or intermediate soft tissue biotype (35, 38, 53, 55, 58, 59).

Importantly, the RIE technique is not intended to replace grafting in cases of true soft or hard tissue deficiency. Instead, it serves as a conservative and biologically favorable alternative for phenotype modification in suitable clinical scenarios. As such, it reflects a broader trend in implant

surgery toward site-preserving, flap-based augmentation techniques, where native tissues are manipulated, rather than replaced, to achieve long-term esthetic and functional outcomes (29, 32, 33, 35, 46, 66).

The RIE technique is one of the two surgical innovations evaluated in this thesis, specifically in comparison to the Holding Suture (HS) method, a more conventional flap stabilization approach.

1.5. The Vestibular Split Rolling Flap in Implant Uncovery

The Vestibular Split Rolling Flap (VSRF) is a minimally invasive, microscope-assisted technique designed for use during the second-stage surgery of submerged implants, when the fixture is surgically exposed and prepared for prosthetic restoration. Developed as a graftless alternative to more invasive uncovery methods, the VSRF approach applies the principles of tissue rolling, partial-thickness dissection, and crestal de-epithelialization to achieve soft tissue volume enhancement directly from the buccal aspect (60, 62, 68-71).

In contrast to traditional mucoperiosteal flaps, the VSRF utilizes a vestibularly based, split-thickness pedicle flap, partially elevated and tunneled to allow for the rolling of de-epithelialized crestal mucosa into the submucosal space. This creates a bulking effect over the buccal contour of the implant, increasing MT and supporting a broader zone of KMW—both critical parameters for the long-term esthetic and functional success of the peri-implant zone (20, 22, 24, 66, 72).

Earlier techniques for soft tissue management during uncovery often relied on full-thickness incisions and apically repositioned flaps, which, while effective in redistributing keratinized tissue, tended to result in tissue shrinkage, vertical scarring, and reduced vestibular depth (29, 45, 73, 74). The VSRF technique mitigates these risks through minimal trauma and precise submucosal placement of the rolled flap, which preserves the mucosal margin and papillary architecture.

A defining advantage of the VSRF technique is its avoidance of horizontal or crestal incisions. Instead, the flap is mobilized through vertical vestibular access, preserving the integrity of the papillae and minimizing disruption to the peri-implant marginal tissues. The flap is then gently rolled and secured in a buccal tunnel using microsurgical sutures, stabilized over a healing abutment previously placed in the implant fixture (17, 29, 60, 69, 70).

This approach was specifically designed to address several limitations of conventional uncovery techniques, such as the Double Door Mucoperiosteal Flap (DDMF). While the DDMF is widely used and predictably distributes keratinized tissue around the implant, it involves full-thickness flap elevation and flap reflection on both the buccal and oral aspects, which can compromise

vascularity and limit soft tissue gain (58, 60, 62, 68, 72). Moreover, the DDMF does not allow for targeted buccal volume enhancement, which is often the critical factor in esthetic and functional optimization, especially in posterior and esthetic zone implants (43, 52).

The VSRF also aligns with microsurgical protocols that emphasize vascular preservation, minimal trauma, and enhanced healing dynamics. The use of high-magnification visualization, fine microblades, and atraumatic suturing contributes to improved tissue handling and reduced postoperative morbidity. These benefits have been observed across other microsurgical applications in both periodontal and implant surgery, where improved vascular stability supports long-term volume retention and tissue health (29, 42-44, 48-51).

Additionally, the rolled flap configuration supports emergence profile development by providing a broader, more stable soft tissue base—particularly useful in molar and premolar regions where contour and hygiene are often challenged. Previous studies have also suggested that submucosal tissue manipulation may influence not only tissue thickness but also the resilience of the peri-implant seal (28, 31, 75).

Importantly, the VSRF is not intended for severe tissue deficiency or ridge augmentation cases. Instead, it offers a refined method for phenotype enhancement at the time of implant uncover—providing a single-stage, graftless solution for shaping peri-implant soft tissues before final prosthetic delivery. Its integration into the implant workflow supports efficient, biologically conservative treatment planning.

This thesis evaluates the VSRF technique in direct comparison with the DDMF approach, analyzing their relative effectiveness in soft tissue volume preservation and long-term mucosal phenotype modification.

1.6. Knowledge Gaps and Justification for This Thesis

Despite the growing interest in graftless, minimally invasive soft tissue augmentation, the scientific literature remains limited with respect to comparative clinical data evaluating these advanced techniques under controlled conditions. Many existing studies on flap-based augmentation either rely on case series with limited follow-up or do not isolate soft tissue manipulation from other surgical variables, such as hard tissue grafting or simultaneous regenerative procedures (34, 36, 37, 44, 52, 76). As such, the specific contributions of flap design and surgical protocol to MT and KMW remain underexplored in the context of modern implant workflows.

In particular, while rolling flap techniques have shown promise in pilot investigations and have been refined through surgical innovation, their long-term performance, biological stability, and clinical reproducibility have not been validated in well-structured, prospective studies using microsurgical protocols (29, 35, 43, 46, 49). Moreover, few studies have addressed the stage-specific application of flap-based techniques—that is, how different rolling flap designs function when deployed at distinct points in the implant treatment timeline, such as placement versus second-stage uncovering (31, 38).

Although CTG remains the gold standard for phenotype modification (77), limitations related to morbidity, surgical time, and inter-patient variability have driven the development of alternatives. However, most graftless solutions to date either rely on soft tissue substitutes or are limited to anterior zones, leaving a significant evidence gap regarding autogenous rolling flaps in posterior sites (27, 53, 65).

The RIE and VSRF techniques were each developed to address specific clinical needs at two separate surgical stages. Yet, prior to this work, there had been no unified clinical investigation exploring both techniques within a common conceptual and methodological framework. Similarly, standard techniques like the HS or DDMF—though widely used—had not been directly compared to these newer rolling-based methods using identical outcome measures, operator protocols, and follow-up intervals.

This thesis aims to address these critical knowledge gaps by presenting two prospective clinical studies that evaluate the RIE versus HS techniques during implant placement and the VSRF versus DDMF techniques during implant uncovering, with a consistent emphasis on soft tissue outcomes, including MT, KMW, and clinical stability over time. By investigating these novel techniques within a controlled, comparative framework, this thesis contributes new data to the evolving body of evidence supporting minimally invasive, graftless, and biologically conservative soft tissue augmentation in implant dentistry. It seeks not only to clarify the effectiveness of specific flap designs but also to reinforce the broader clinical paradigm of using precisely executed autogenous tissue techniques to optimize peri-implant health and esthetics.

II. OBJECTIVES

This thesis draws on two prospective clinical studies that investigated the clinical effectiveness of minimally invasive, microscope-assisted techniques for peri-implant soft tissue management, applied at distinct stages of implant therapy.

The primary objective of the first study (78) was to compare the performance of the roll-in envelope flap (RIE) technique with the more conventional holding suture (HS) approach during implant placement. The main focus was on the preservation of mucosal thickness (MT), measured at 6 and 12 weeks postoperatively. The RIE technique, which involved rolling de-epithelialized mucosa into a buccal envelope, was designed to stabilize and thicken the peri-implant soft tissue without requiring autogenous grafting. As a secondary objective, this study also examined patient-reported outcomes, including postoperative pain and discomfort, in order to assess whether the reduced invasiveness of the RIE technique translated to improved patient experience and faster recovery.

The primary objective of the second study (79) was to evaluate the clinical outcomes of the vestibular split rolling flap (VSRF) in comparison with the double door mucoperiosteal flap (DDMF) during implant uncoverly (second-stage surgery). The investigation centered on changes in keratinized mucosal width (KMW) and vestibular mucosal thickness (MT) over a 12-month period, using standardized soft tissue measurements. The VSRF technique, which utilized a vestibularly pedicled and split-thickness flap tunneled and rolled into the buccal aspect, was intended to enhance soft tissue volume while maintaining vascular integrity. As a secondary objective, the study assessed the long-term stability of the augmented tissues and the clinical feasibility and reproducibility of the technique when performed under magnification.

Both studies aimed to determine the clinical feasibility of these novel techniques in a routine surgical setting. Feasibility was assessed in terms of technical execution, healing response, patient tolerance, and procedural reproducibility when performed under microscope-assisted conditions. By focusing on native tissue manipulation and excluding grafting or biomaterial use, the goal was to validate whether the RIE and VSRF techniques could serve as viable, biologically conservative alternatives to traditional augmentation approaches in appropriate cases.

III. METHODS

III.1. Study One: RIE vs. HS in Implant Placement

III.1.1. Study Design and Subject Recruitment

This investigation was conducted as a prospective pilot case series involving the placement of 10 single posterior dental implants in 10 systemically healthy, non-smoking adult participants. Each patient was randomly assigned to receive either the Roll-in Envelope Flap (RIE; Group A) or the Holding Suture Flap (HS; Group B) technique at the time of implant placement.

Randomization was performed using a computer-generated sequence, and allocation was managed by clinical research staff who communicated the assignments to the operator (B.S.).

All implant placements were preceded by digital planning, confirmed by cone-beam computed tomography (CBCT), and carried out on average 3.5 months following minimally invasive tooth extractions combined with alveolar ridge preservation. The preservation procedure involved the use of a xenogenic bone substitute (Bio-Oss Granules, Geistlich Pharma AG, Wolhusen, Switzerland) and a Stypro Gelatin sponge (Curasan AG, Kleinostheim, Germany) [19].

Implants placed were either Straumann Bone Level Tapered (Institut Straumann AG, Basel, Switzerland) or Dentsply XIVE (Dentsply Sirona, Charlotte, North Carolina, USA). The surgeries were performed between December 2019 and December 2021.

All participants provided written informed consent prior to inclusion. The study adhered to the ethical principles of the Declaration of Helsinki concerning research involving human subjects.

III.1.2. Surgical Procedure

The 10 patients were equally allocated into two groups of five, each receiving either the Roll-in Envelope Flap (RIE) or the Holding Suture Flap (HS) approach.

All surgical procedures were carried out by the same experienced operator (B.S.) using a surgical microscope (Zeiss Extaro 300, Oberkochen, Germany) under uniform magnification.

For the RIE technique (Figure 1), the procedure began with the de-epithelialization of the soft tissue at the planned implant site using a round diamond bur (1 mm diameter) (Figure 1A). A microsurgical blade (Swann Morton LTD., Sheffield, England) was then used to make two bucco-lingual incisions and one mesiodistal incision to outline a square-shaped flap (Figure 1B). The bucco-lingual incisions started at the buccal line angle of the neighboring teeth, keeping a 1–2 mm safety distance from the adjacent sulci to preserve the papillae. The bucco-lingual extension of the

flap extended roughly 3 mm beyond the sagittal midline of the alveolar crest, while the vestibular extension reached 1–2 mm beyond the crestovestibular margin. The overall sagittal length of the flap was on average 2 mm wider than the planned implant diameter (1 mm on each side). A split-thickness flap was then raised using a micro-elevator (Figure 1C).

Subsequently, the elevated flap was rolled into the prepared vestibular envelope, and the implant was placed at the designated site (Figure 1D). The rolled flap was stabilized with two vertical mattress sutures using 6–0 Seralon sutures (Serag-Wiessner, Naila, Germany) (Figure 1E). The sutures penetrated both layers of the rolled mucosa and the matching point on the crestal-oral mucosa to secure the flap on the mesial and distal sides of the implant.

In the HS group (Figure 2A), the surgical procedure began with a split-thickness incision, performed perpendicularly to the mucosal surface using a microsurgical blade. This incision followed a vestibularly pedicled rectangular flap design, closely mirroring the configuration employed in the RIE group. The flap extended 1 to 2 mm beyond the sagittal midline of the alveolar crest, allowing for sufficient soft tissue volume to enable the subsequent rolling maneuver. Once the flap was carefully elevated, it was folded back over itself and temporarily secured in position by placing a 6–0 microsuture underneath both layers of the tissue (Figure 2B). Implant placement was then carried out under magnification with the flap held in place (Figure 2C). Following implant insertion, the holding suture was removed, and the mobilized flap was repositioned by rolling it into the buccal aspect of the soft tissue. The final stabilization of the flap was accomplished using vertical mattress sutures in the same manner as in the RIE group (Figure 2D,E).

Following irrigation and cleansing of the internal implant site, healing abutments treated with 1% chlorhexidine gel (GlaxoSmithKline Consumer Healthcare GmbH & Co. KG, Munich, Germany) were inserted into the fixtures (Figures 1E and 2D).

All patients received postoperative instructions and medications, including clindamycin 300 mg (Ratiopharm GmbH, Ulm, Germany) for 3 days and ibuprofen 400 mg (Ratiopharm GmbH) as needed. Comprehensive oral hygiene instructions were also provided. Sutures were removed between 10 and 14 days post-surgery in all patients.

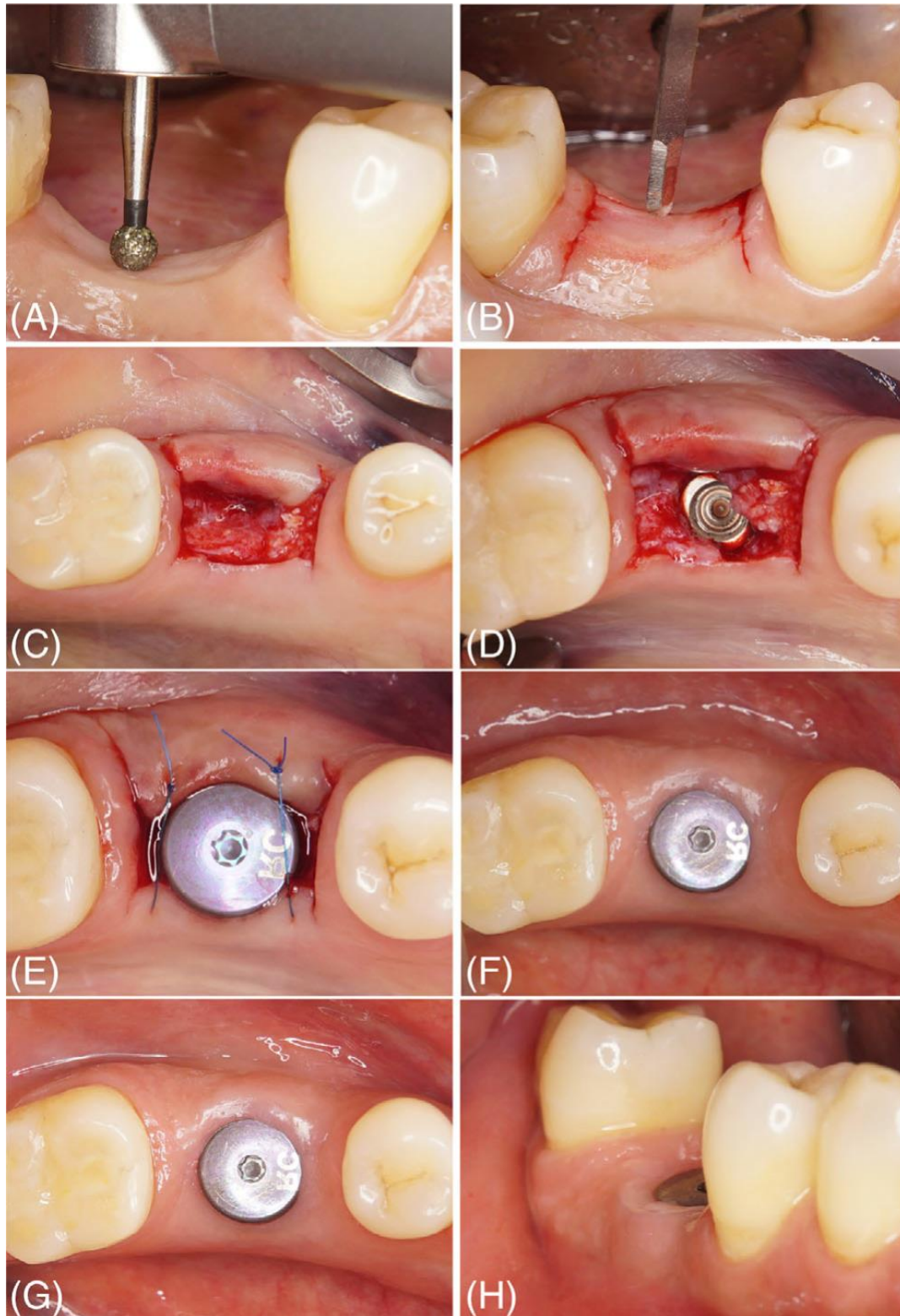


Figure 1. The roll-in-envelope flap technique. (A) Pre-operative image showing the maxillary first premolar site with initial de-epithelialization using a round diamond bur. (B) Flap outline established. (C) Mucosal flap rolled into the prepared vestibular envelope. (D) Flap maintained in position throughout implant placement. (E) Micro-fixation of flap with 6–0 sutures after healing screw placement. (F) 6-week follow-up. (G) 12-week follow-up. (H) Buccal view at 12 weeks.

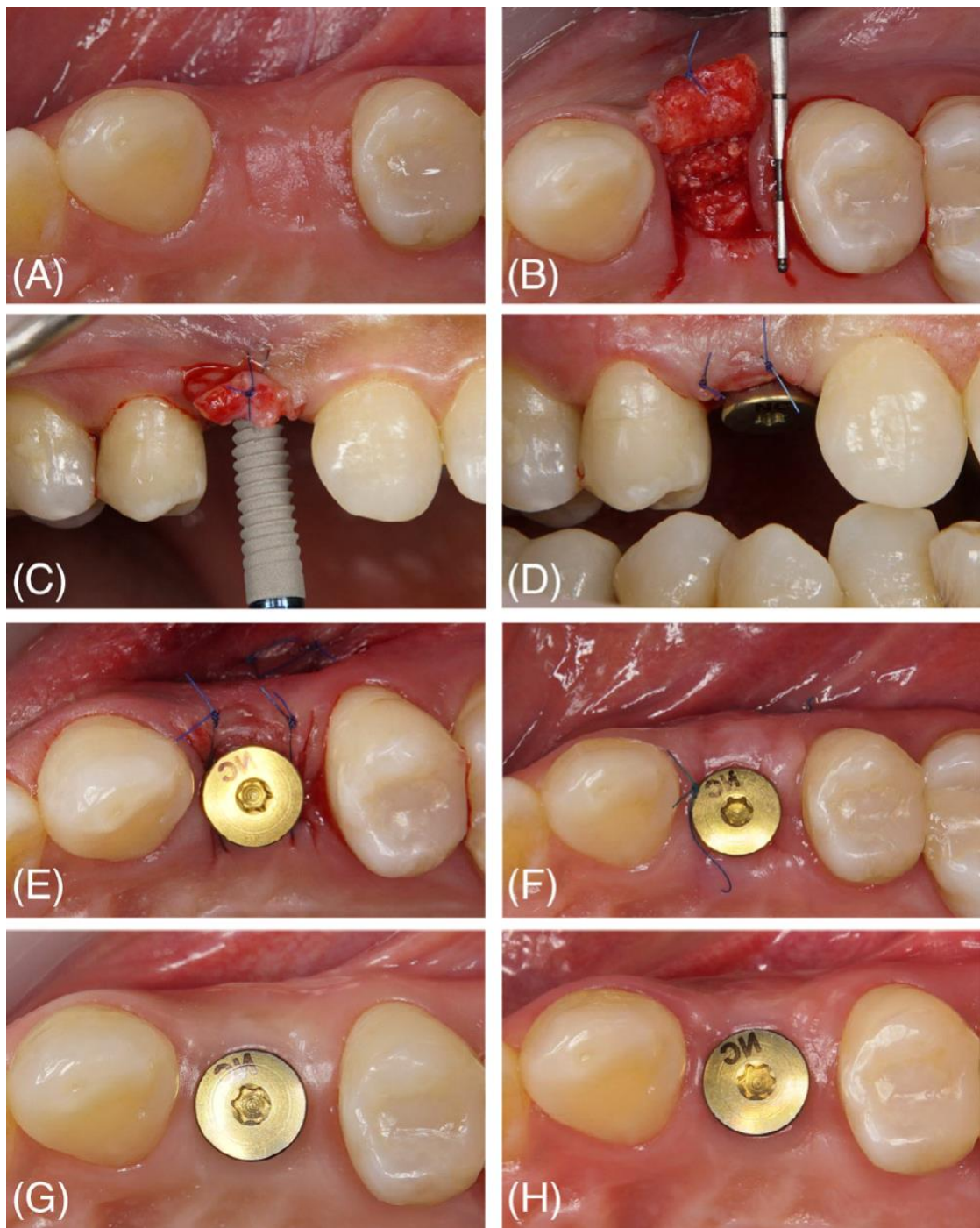


Figure 2. The holding suture flap technique. (A) Pre-operative view of the maxillary first premolar region. (B) Holding suture stabilizing the folded flap. (C) Implant placement while flap is held in position. (D) Healing abutment inserted, flap repositioned and rolled into buccal soft tissue. (E) Buccal post-operative view. (F) Healing after 10 days (occlusal view). (G) 6-week follow-up. (H) 12-week follow-up.

III.1.3. Study Outcomes and Assessment of Peri-Implant Soft Tissue Thickness

All participants were recalled at standardized follow-up intervals of 6 and 12 weeks postoperatively to evaluate the healing of the peri-implant soft tissues [Figures 1F–H and 2F–H]. The primary clinical parameter assessed was the horizontal thickness of the buccal peri-implant mucosa, measured in the vestibule-to-margin direction. This was defined as the peri-implant buccal mucosal thickness.

All measurements were conducted under standardized conditions using direct microscopic visualization. A single calibrated examiner (B.S.) performed the assessments using a UNC-15 periodontal probe (Hu-Friedy, Chicago, IL, USA). Figure 3 shows the soft tissue conditions before and after implant placement applying the RIE technique.

As this was a pilot technical comparison study, all clinical outcomes were reported descriptively. No inferential statistical analyses were applied.

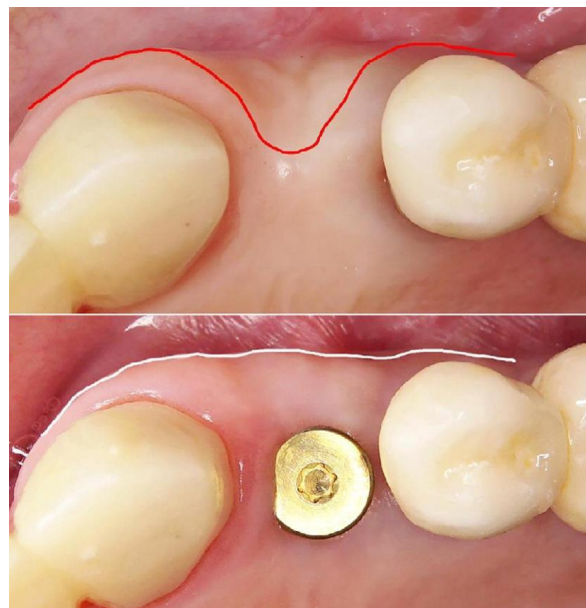


Figure 3. Comparison of the conditions of the vestibulo-gingival soft tissue before (top) and 12 weeks after (bottom) the implant placement (RIE).

III.2. Study Two: VSRF vs. DDMF in Implant Exposure

III.2.1. Study Design and Recruitment

This research was structured as a prospective clinical study evaluating the clinical performance of two surgical techniques for implant exposure: the vestibular split rolling flap (VSRF) and the

double door mucoperiosteal flap (DDMF). A total of 44 adjacent posterior dental implants were uncovered at the second-stage surgery in 10 systemically healthy, non-smoking patients.

All participants provided written informed consent prior to inclusion. The study adhered to the ethical principles of the Declaration of Helsinki concerning research involving human subjects.

Implant sites were treated using both techniques within each patient: the mesial implants were consistently assigned to the VSRF technique (Group A), and the distal implants to the DDMF technique (Group B). All implants were located adjacent to one another, thereby allowing intra-individual comparison under standardized anatomical and clinical conditions.

Implant therapy had been performed using either Straumann Bone Level Tapered (Straumann) or Dentsply XIVE (Dentsply Sirona) systems, and was carried out between April 2015 and December 2017. On average, implant placement took place 3.5 months following minimally invasive tooth extraction combined with alveolar ridge preservation using a xenogenic bone substitute (Bio-Oss Granules; Geistlich Pharma) and a Stypro gelatin sponge (Curasan). Surgical planning was conducted digitally and three-dimensionally using commercially available software (3Shape) (Figure 4), and patient-specific CAD/CAM-fabricated surgical guides were employed during implant placement.

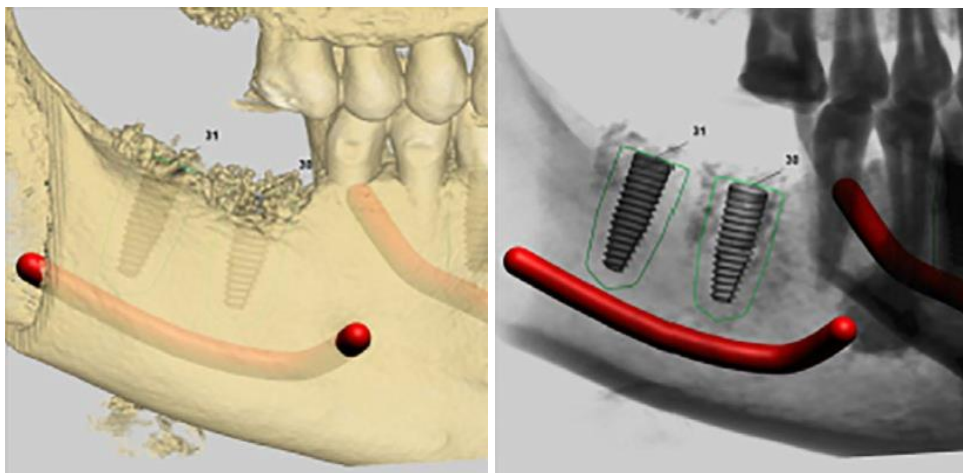


Figure 4. The implant surgeries were planned digitally and three-dimensionally using 3Shape software. Virtual planning ensured prosthetically driven positioning and guided implant placement.

Second-stage surgical exposure occurred between June 2015 and March 2018, with final study measurements completed in August 2019 — six months after delivery of all final implant-supported restorations.

Inclusion criteria required that both implant sites in each patient exhibit comparable soft tissue volume prior to uncover, with similar vestibular and crestal soft tissue profiles, including keratinized mucosal width (KMW) and mucosal thickness (MT), measured by a single calibrated operator (B.S.) using a periodontal probe. Implants exhibiting vestibular or oral ridge deformities were excluded.

All patients were systemically and periodontally healthy, nonsmokers, and willing to adhere to the clinical protocol and attend all follow-up visits. Preoperative KMW values ranged from 2 to 4 mm, and MT values were between 1 and 2 mm. These parameters were consistent between the mesial and distal implant sites in each patient (Figures 5 and 6).



Figure 5. Clinical presentation two months post-implant placement in regions 36, 46, and 47. Residual amalgam tattoos are visible at the respective implant sites, along with pre-existing enamel chipping that had been identified for future restoration.

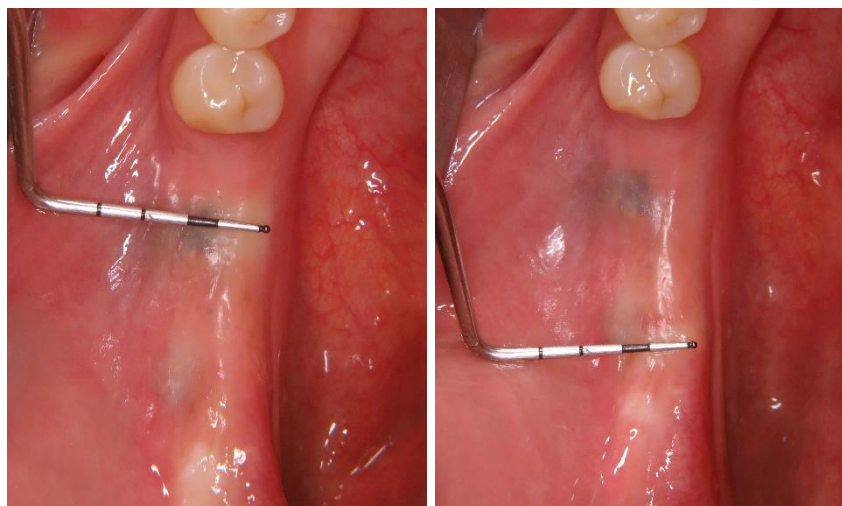


Figure 6. Measurement of crestal keratinized mucosal width (KMW) prior to surgical uncover at the mesial implant site planned for VSRF (left) and the distal site planned for DDMF (right).

Where insufficient vestibular depth was present, localized vestibuloplasty was performed two months prior to implant uncovering in order to avoid post-operative tension on the soft tissues. This procedure was carried out in three patients.

III.2.2. Surgical Procedure at the Second Stage

The full clinical workflow and procedures performed on both adjacent implants were documented over a period of one year. Figure 5 provides a composite overview of the clinical progression over the one-year period following implant exposure, including key time points such as immediate post-operative status, early healing, and final restoration.

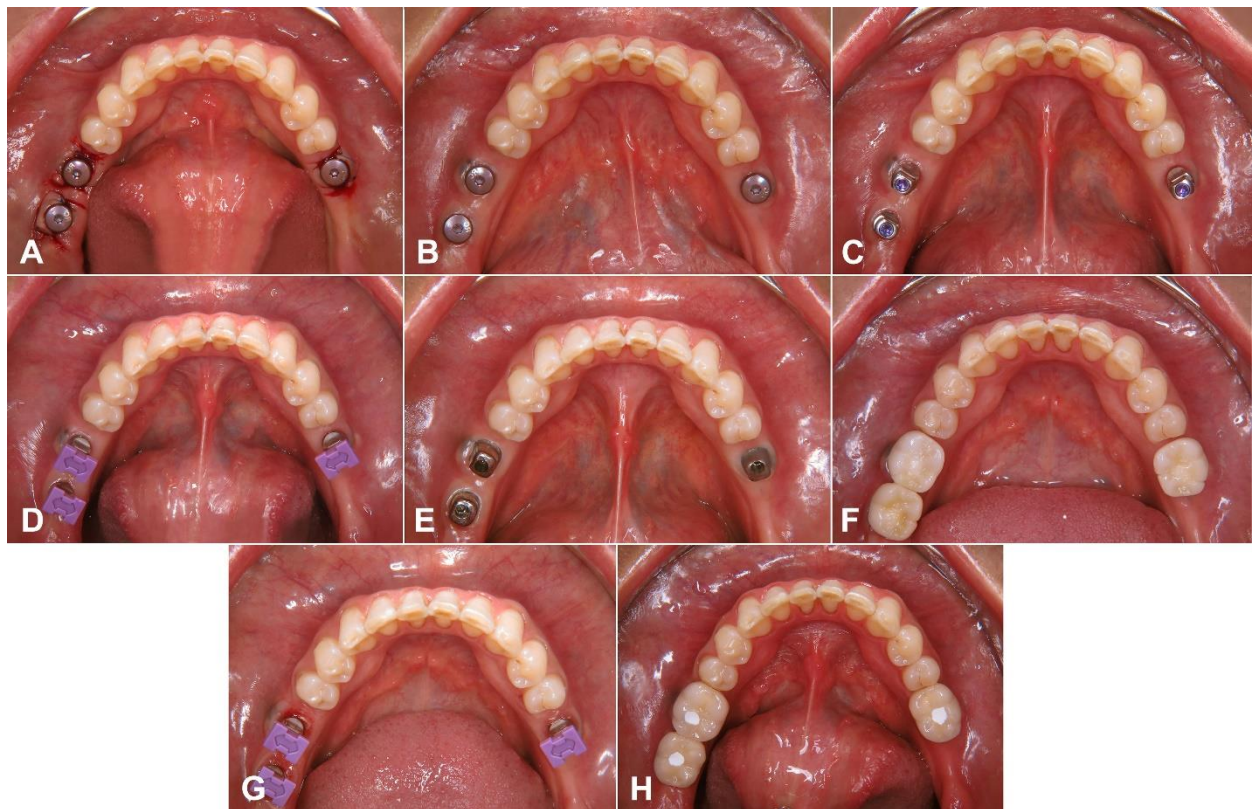


Figure 5. Chronological clinical overview following implant exposure. Composite of intraoral images showing the progression of soft tissue healing and prosthetic treatment over 12 months: (A) immediately after implant exposure; (B) 1 month post-exposure; (C, D) 2 months post-exposure at the time of first impression for provisional restorations; (E) 2.5 months post-exposure during insertion of customized abutments and provisional crowns; (F) 6 months post-exposure and 3.5 months after provisional insertion; (G) 7 months post-exposure at the time of second-stage impression for final restorations; (H) 12 months post-exposure and 4 months after placement of screw-retained e.max crowns with customized zirconia abutments.

Following administration of local anesthesia, the submucosal positions of both mesial and distal implants were located using an implant finder device (Dentsply). For mesial implants, the vestibular split rolling flap (VSRF) technique (Group A) was applied as follows (Figure 6): a

mucosal incision was made using a Micro or 15C blade (Swann-Morton), creating a vestibularly pedicled rectangular flap. This incision extended 1 to 2 mm over the sagittal midline of the crest to allow sufficient tissue for the roll-in procedure. The vestibular extension continued 1 to 2 mm past the crestovestibular border. The sagittal flap length was approximately 2 mm greater than the implant diameter (1 mm to both mesial and distal sides).

After visualizing the future papillary architecture, the DDMF technique (Group B) was applied to the distal implant. A crestal midline incision was made in a double door or "H" flap design using the same blade type. The vestibular flap was pedicled to the buccal side and extended 1 to 2 mm beyond the crestovestibular margin. The oral flap was pedicled to the lingual side and extended about 2 mm. The sagittal length of both flaps matched that of the VSRF.

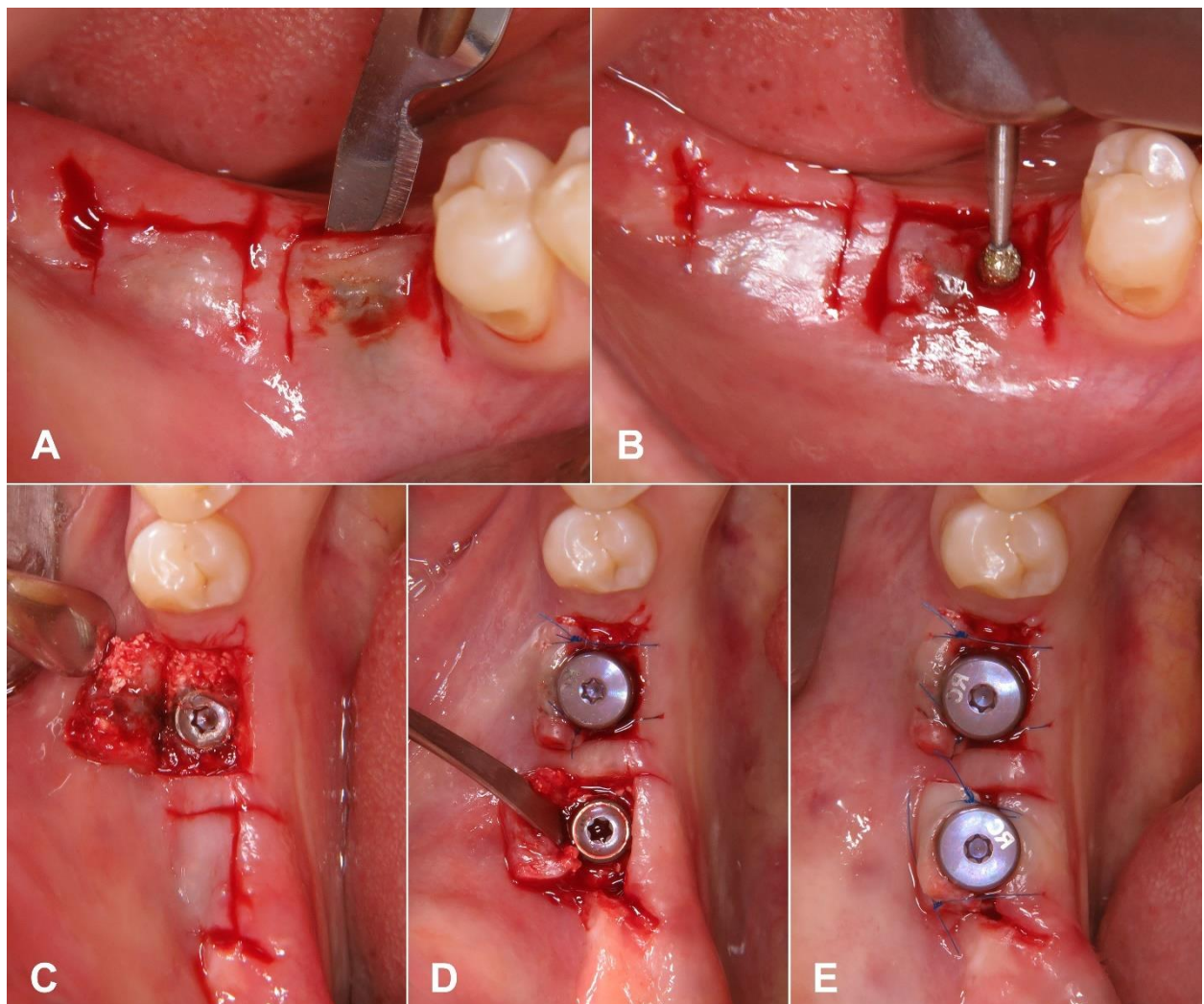


Figure 6. Key stages of flap elevation and preparation in the VSRF and DDMF techniques. (A) Splitting and partial elevation of the VSRF prior to deepithelialization from the vestibular aspect; (B) careful deepithelialization of the crestal part of the VSRF before rolling the flap; (C) full elevation of the partial-thickness flap revealing periosteum and residual xenogeneic graft material; (D) occlusal view showing completed VSRF (region 6) and preparation of the adjacent DDMF site (region 7); (E) occlusal view after completion of both VSRF and DDMF procedures.

In Group A, the crestal segment of the flap was carefully deepithelialized using a 1-mm round diamond bur. A partial-thickness flap was then elevated at a 45-degree angle to preserve the periosteum. A 3-mm sub-crestal tunneling dissection was performed to create space for the rolled tissue.

In Group B, the vestibular and oral flaps were elevated only up to the crestal edge, without tunneling.

Implant cover screws were removed, and healing abutments were selected to protrude 2 to 3 mm above the expected soft tissue margin following suturing. All abutments were soaked in 1% chlorhexidine gel (GlaxoSmithKline Consumer Healthcare) and inserted into the implants.

In the VSRF group, the deepithelialized flap was gently rolled into the vestibular tunnel using a micro-elevator and held in place with micro-pincettes. It was stabilized using a 6-0 vertical mattress Seralon suture (Serag-Wiessner), passing through both rolled tissue layers and penetrating the corresponding crestal-oral mucosa to anchor the flap mesially and distally.

In the DDMF group, the same suture material and technique were used; however, since no rolled tissue was present, the suture penetrated only a single vestibular flap layer.

All patients were prescribed postoperative clindamycin 300 mg (Ratiopharm) for 3 days, and ibuprofen 400 mg (Ratiopharm) as needed. Oral hygiene instructions and postoperative care guidelines were provided to each patient.

Digitally designed, customized provisional zirconia crowns were delivered with contoured abutments to guide emergence profile formation prior to final prosthetic restoration with layered e.max crowns.

III.2.3. Study Outcomes and Reporting

The aim of this study was to evaluate changes in peri-implant soft tissues by monitoring two parameters on the vestibular aspect of each implant: mucosal thickness (MT) and keratinized mucosal width (KMW). Both parameters were assessed at four time points:

1. Immediately after surgical implant uncovering
2. 1 month postoperatively
3. 6 months postoperatively (first recall)
4. 12 months postoperatively (on average 4 months after final prosthetic delivery)

All measurements were performed by the same calibrated examiner (B.S.) using a periodontal probe. Due to the pilot design of this technical comparison, outcomes were reported descriptively, and no statistical inferences were made.

In Group A (VSRF), the mean vestibular mucosal thickness at 12 months was 2.5 ± 0.2 mm, while in Group B (DDMF) it was 1.0 ± 0.3 mm. The mean keratinized mucosal width was also greater in Group A (2.5 ± 0.2 mm) compared to Group B (2.0 ± 0.3 mm).

Healing was uneventful in all cases, with no patient drop-outs or adverse events. Each implant successfully received its final restoration.

IV. RESULTS

IV.1. Results of Study One: RIE vs. HS

IV.1.1. Sample Characteristics and Clinical Outcomes

In accordance with the study protocol, a total of 10 single dental implants were placed in the posterior maxilla or mandible of 10 healthy, systemically stable patients. The cohort consisted of 6 females and 4 males, with a mean age of 38.2 ± 15.4 years.

Healing was uneventful in all implant sites. There were no reported adverse events, complications, or dropouts. All patients completed the treatment as planned and received final prosthetic restorations.

IV.1.2. Peri-Implant Mucosal Thickness Measurements

At baseline, the mean mucosal thickness at the implant sites was 3.2 mm in the RIE group and 2.4 mm in the HS group, indicating a moderately thicker soft tissue profile in the RIE-treated sites prior to intervention. At the 6-week follow-up, these values slightly decreased to 3.0 mm in the RIE group and 2.5 mm in the HS group.

By the 12-week evaluation, both groups exhibited a measurable reduction in mucosal thickness. In the RIE group, the decrease averaged 0.4 mm, resulting in a final mucosal thickness of 2.5 mm. In contrast, the HS group experienced a more pronounced reduction of 1.2 mm, yielding a final average thickness of 1.5 mm.

When soft tissue loss was compared across time points, the average reduction at 6 weeks in the HS group was 0.4 mm, whereas the RIE group showed only 0.2 mm loss. By 12 weeks, the tissue reduction in the HS group was approximately threefold greater than that observed in the RIE group, highlighting the superior dimensional stability associated with the RIE technique (Figure 7 and Figure 8).

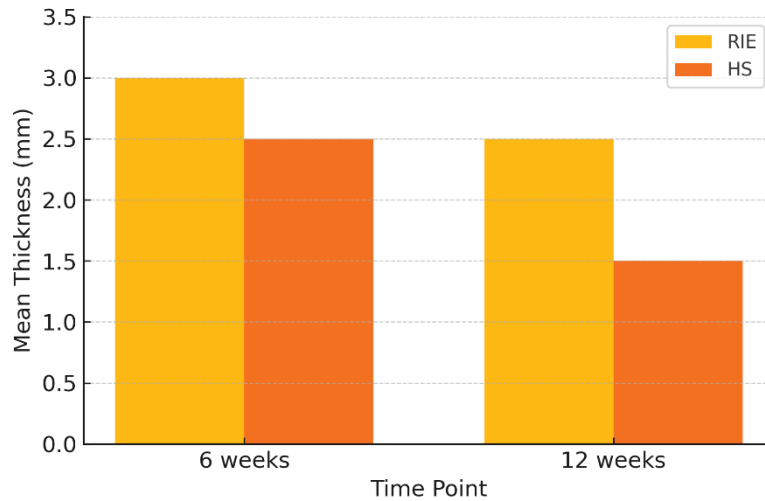


Figure 7. Mean absolute mucosal thickness (in mm) at 6 and 12 weeks postoperatively for the Roll-in Envelope (RIE) and Holding Suture (HS) groups.

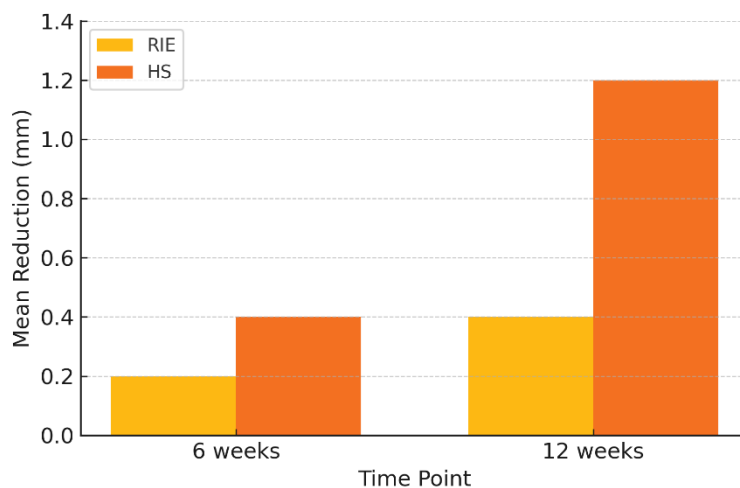


Figure 8. Comparison of the mean reduction in buccal soft tissue thickness at different time points of the study.

IV.2. Results of Study Two: VSRF vs. DDMF

IV.2.1. Sample and Healing Overview

Ten systemically healthy, non-smoking patients (8 females and 2 males), aged 35 to 58 years, were included in the study. A total of 44 posterior dental implants were evaluated, with 18 placed in the maxilla (6 premolars and 12 molars) and 26 in the mandible (10 premolars and 16 molars).

Healing was uneventful at all sites. No patients dropped out, and no adverse events were recorded during the entire observation period. All implants successfully received their planned final prosthetic restorations.

At baseline (prior to uncover), the average vestibular mucosal thickness (MT) was 1.6 mm in the VSRF group and 1.8 mm in the DDMF group. The baseline keratinized mucosal width (KMW) ranged from 2.5 to 4 mm and was comparable across both groups.

By the end of the study period, all implants had been restored with customized healing abutments and cemented CAD/CAM zirconia crowns, with identical materials and procedures applied in both groups.

IV.2.2. Changes in Mucosal Thickness and Keratinized Tissue Width

For this section, the quantitative results are presented in Figures 9 and 10, while Figures 11 to 14 illustrate the clinical progression over time. Due to space limitations, only the most representative figures have been included. For the complete set of clinical images, please refer to the original publication.

At the 1-month follow-up, a slight reduction in mucosal thickness (MT) was noted in both groups. This change was visible under optical magnification. While the MT appeared qualitatively similar between groups at this stage, a reduction of approximately 0.5 mm in keratinized mucosal width (KMW) was observed in both the VSRF and DDMF groups.

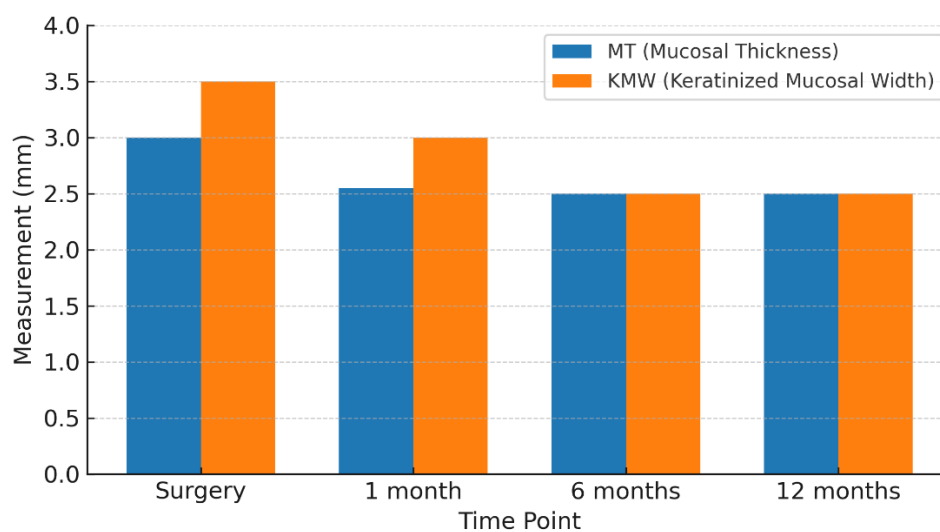


Figure 9. Temporal development of mean MT and KMW in the VSRF group over a 12-month period following implant exposure.

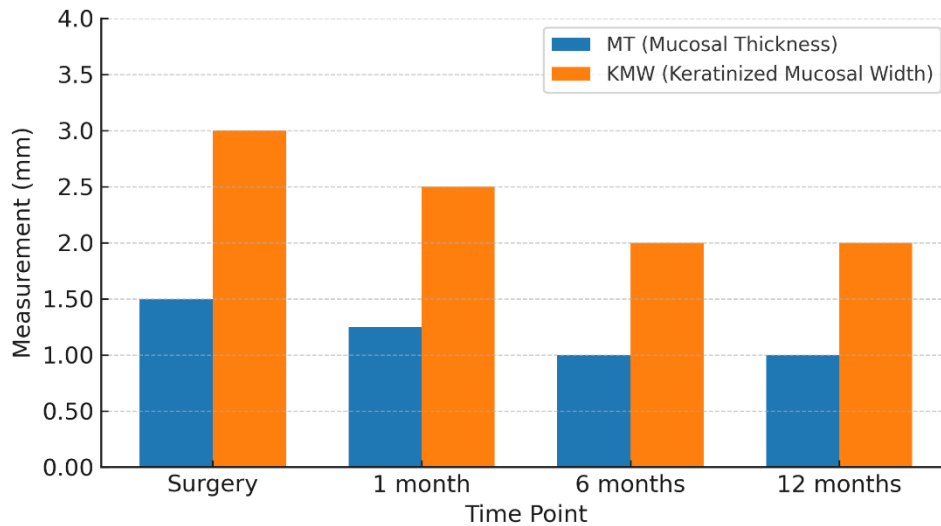


Figure 10. Temporal development of mean MT and KMW in the DDMF group over a 12-month period following implant exposure.

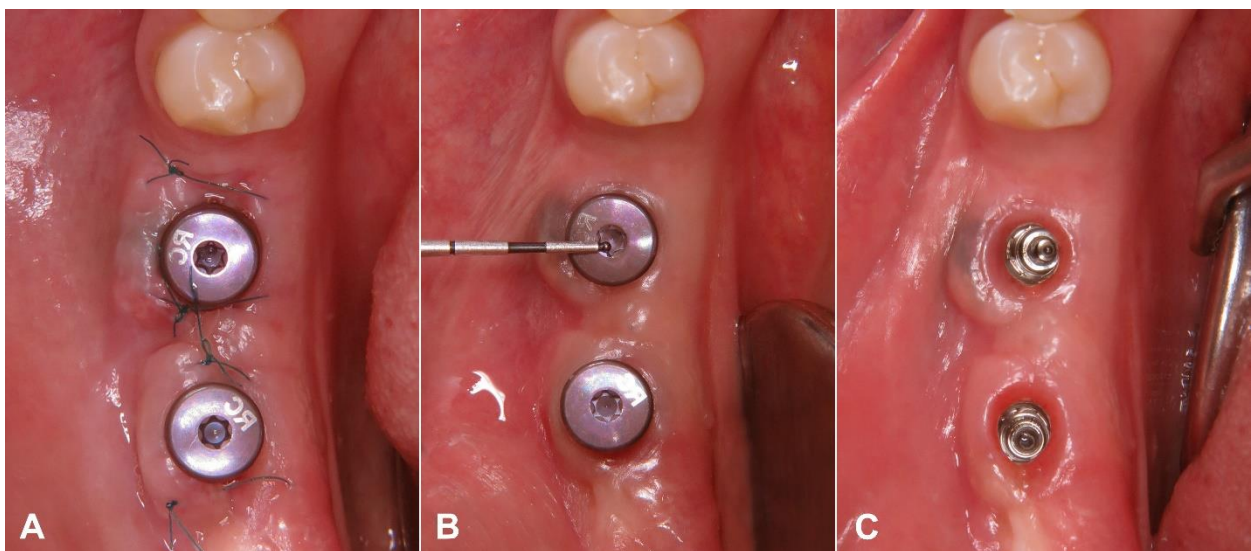


Figure 11. Occlusal view of the healing progression following implant exposure. (A) Twelve days postoperatively, showing uneventful early healing; (B) one month postoperatively; (C) three months postoperatively, highlighting the visible difference in mucosal thickness between the two implant sites.

Between 1 and 6 months postoperatively, both MT and KMW continued to decrease slightly in both groups. From the first to the sixth month, a gradual reduction of less than 0.5 mm in both parameters was observed. The final all-ceramic restorations were inserted approximately 8 months after the uncover procedures, once emergence profiles had been shaped with provisional restorations.



Figure 12. Clinical situation following delivery of customized zirconia temporary crowns. Left: vestibular view at 2 months post-delivery and 5 months after implant exposure. Right: occlusal view at 3 months post-delivery, showing persistent vestibular keratinized mucosa volume difference and signs of superficial inflammation due to cement impaction.

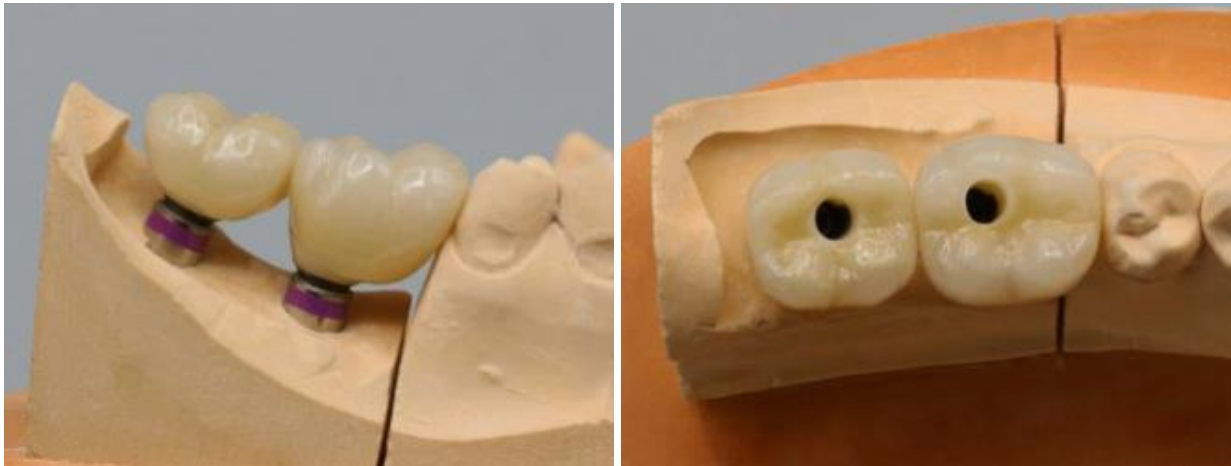


Figure 13. The final e.max screw-retained crowns on the cast shortly before oral insertion from the vestibular (left) and the occlusal (right) views.

At the 12-month follow-up — which occurred about 4 months after delivery of the final restorations — no significant changes were recorded compared with the 6-month results. Overall, both groups showed a two- to three-fold increase in mucosal thickness at 1 year compared to baseline. However, the KMW was consistently slightly higher in the VSRF group. At the 12-month follow-up, the VSRF group demonstrated greater soft tissue dimensions than the DDMF group. The mean mucosal thickness (MT) measured 2.5 mm in the VSRF group, compared to 1.0

mm in the DDMF group. Similarly, the mean keratinized mucosal width (KMW) was 2.5 mm for VSRF and 2.0 mm for DDMF.

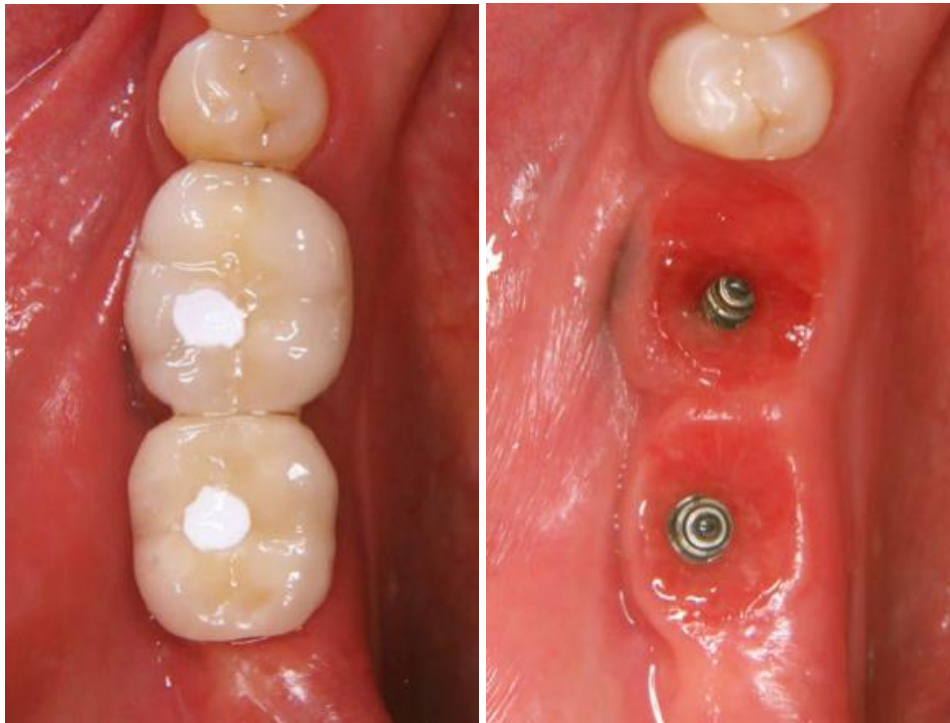


Figure 14. Clinical situation 5 months after insertion of the final screw-retained e.max crowns and 1 year after implant exposure. Left: occlusal view showing the established emergence profile; right: vestibular view illustrating the distinct difference in peri-implant keratinized mucosal volume between the two implant sites.

V. DISCUSSION

V.1. Overview of Microsurgical Soft Tissue Augmentation

The evolution of soft tissue management in implant dentistry has increasingly emphasized the role of phenotype optimization through minimally invasive, autogenous approaches. Both clinical studies presented in this thesis reflect this paradigm shift, moving away from traditional graft-based protocols toward surgical techniques that rely on manipulation of the native peri-implant mucosa. These techniques—Roll-In Envelope Flap (RIE) during implant placement and Vestibular Split Rolling Flap (VSRF) during second-stage uncover—represent a biologically conservative alternative to conventional grafting and biomaterial-based augmentation.

This shift is not merely procedural but conceptual. The growing recognition that peri-implant soft tissue phenotype significantly affects long-term esthetic and functional outcomes has led to an increased focus on preserving or enhancing mucosal thickness (MT) and keratinized mucosal width (KMW). Both are considered critical for maintaining peri-implant health, esthetic contour, and resistance to mechanical and microbial insult (15-17, 20, 24). The ability to stabilize these tissues without the use of autogenous connective tissue grafts (CTGs) offers both biological and procedural advantages.

A central enabler of these techniques is the use of magnification-assisted microsurgery. The integration of operating microscopes and microsurgical instruments allows for fine dissection, improved visibility, and enhanced flap control. This is particularly relevant in flap-based augmentation, where preservation of vascular supply and tension-free closure determine the success of volume stability and wound healing (46, 48, 49, 51). Both RIE and VSRF were performed under magnification, underscoring the importance of visual precision in soft tissue preservation protocols.

Importantly, neither technique introduces foreign graft material or requires a secondary donor site. Instead, both procedures repurpose native tissue through controlled elevation, repositioning, and stabilization. This approach minimizes surgical trauma, reduces postoperative morbidity, and may improve patient acceptance, especially in anatomically favorable posterior cases (29, 32, 33). As demonstrated in the presented studies, the avoidance of palatal harvesting or collagen substitutes did not compromise outcomes, and soft tissue volume was preserved or enhanced through autogenous manipulation alone.

Taken together, these techniques reflect a broader evolution in implant therapy—toward biologically driven, tissue-sparing protocols that prioritize phenotype enhancement without over-reliance on grafting. The RIE and VSRF methods are situated within this modern framework: autogenous, flap-based, microscope-assisted, and adaptable to stage-specific clinical objectives. Their application supports the fundamental goal of preserving peri-implant soft tissue health while reducing surgical invasiveness.

V.2. Interpretation of Findings: Study 1 (RIE vs. HS)

The first clinical study examined the performance of the Roll-In Envelope (RIE) flap compared to the conventional Holding Suture (HS) technique during implant placement. The findings demonstrated that the RIE method was associated with superior preservation of buccal mucosal thickness (MT) during the 12-week postoperative period. While both groups exhibited uneventful healing, the reduction in horizontal soft tissue volume was significantly lower in the RIE group—approximately 0.4 mm versus 1.2 mm in the HS group. This threefold difference highlights the capacity of the RIE technique to preserve soft tissue architecture during early healing.

This clinical effect can be attributed to specific biological and mechanical features of the RIE approach. Through partial-thickness dissection and crestal de-epithelialization, the rolled mucosal flap creates a stable submucosal volume that resists collapse. The use of microscope-assisted vertical mattress sutures—passing through both the rolled tissue and the crestal oral mucosa—ensures precise flap positioning and compression, promoting wound stability. These principles are consistent with prior reports that emphasize the importance of controlled tissue repositioning and vascular integrity in autogenous flap designs (43, 53, 55, 58, 59).

In contrast to techniques relying on CTGs, the RIE method avoids donor site morbidity and reduces surgical time while still supporting phenotype preservation. This reflects a broader movement toward graftless alternatives that minimize invasiveness without compromising clinical outcomes (29, 32, 33). Studies have shown that thickening the peri-implant soft tissue, even without additional graft material, improves marginal stability and esthetic predictability (15-21, 23).

Microsurgical visualization is also a defining component of this protocol. Previous literature has demonstrated that magnification improves flap handling, enhances vascular preservation, and reduces postoperative complications (46-48, 57). In the present study, consistent surgical execution under magnification may have contributed to the favorable outcomes in the RIE group, particularly in terms of flap stability and soft tissue contour.

Nonetheless, several limitations must be acknowledged. The study was conducted as a pilot series with only ten patients and without statistical testing. Although the clinical differences between groups were clear and reproducible, the lack of quantitative imaging or volumetric analysis limits generalizability. Furthermore, no patient-reported outcome measures (PROMs) were included to assess discomfort, recovery, or satisfaction—parameters increasingly relevant in the evaluation of minimally invasive techniques (29, 32, 33).

In summary, the RIE technique demonstrated a distinct advantage over the HS method in terms of peri-implant tissue preservation during early healing. Its effectiveness supports the principle that autogenous tissue, when repositioned under microsurgical conditions, can serve as a viable alternative to grafting for phenotype enhancement in appropriately selected posterior sites.

V.3. Interpretation of Findings: Study 2 (VSRF vs. DDMF)

The second clinical study investigated the Vestibular Split Rolling Flap (VSRF) in comparison with the Double Door Mucoperiosteal Flap (DDMF) for implant uncovering. Over a 12-month follow-up period, VSRF demonstrated a clear advantage in increasing and maintaining both buccal mucosal thickness (MT) and keratinized mucosal width (KMW). The mean MT at 12 months was 2.5 ± 0.2 mm in the VSRF group versus 1.0 ± 0.3 mm in the DDMF group. KMW was also consistently higher in the VSRF sites throughout the study period. These findings reinforce the VSRF technique's efficacy as a graftless, stage-specific augmentation method.

The superior performance of VSRF is attributable to its biologically conservative design. By employing a split-thickness, vestibularly based flap and directing the rolled, de-epithelialized tissue into a prepared submucosal tunnel, VSRF achieves targeted volume enhancement while preserving vascular supply (62, 68, 72). In contrast, DDMF relies on full-thickness bilateral flap elevation, which redistributes soft tissue but does not increase its thickness and may compromise perfusion (52, 58). These differences are clinically significant, particularly in posterior sites where mucosal resilience and prosthetic emergence profile are critical for long-term success (20, 22, 24).

The stability of results over time further supports the efficacy of VSRF. Following an expected initial remodeling phase, MT and KMW in the VSRF group remained consistent from 6 to 12 months. This suggests that the rolled tissue, when stabilized under a healing abutment, maintains its volume and integration over the medium term—a finding consistent with prior reports on graftless autogenous soft tissue techniques (42-44).

Microsurgical execution played a critical role in this protocol. Use of magnification, microblades, and precision suturing improved flap control and minimized trauma, which has been shown to

enhance vascular stability and healing quality (48, 51). In this regard, VSRF aligns with current microsurgical principles applied to soft tissue augmentation in both periodontal and implant contexts.

While DDMF remains a widely used and predictable method for implant uncover, its limitations in augmenting soft tissue volume and in preserving marginal tissue integrity are evident in this comparison. The lack of rolled or pedicled tissue repositioning restricts its potential in phenotype enhancement. Prior studies have similarly noted that conventional full-thickness flaps are limited in their ability to produce sustained volumetric gains without supplemental grafts (29, 45, 71).

Despite the promising outcomes, certain limitations of the present study must be acknowledged. As a descriptive prospective study, it did not include statistical analysis or objective volumetric imaging. PROMs were not assessed, although previous work has shown that graftless soft tissue techniques are generally associated with improved patient-reported comfort and satisfaction (32, 35). Furthermore, potential operator bias cannot be excluded, as all procedures and evaluations were performed by the same clinician.

In conclusion, the VSRF technique provided clinically meaningful and stable improvements in soft tissue phenotype compared to DDMF. These findings support the role of VSRF as a minimally invasive, biologically favorable method for soft tissue enhancement during the second-stage implant surgery, particularly in cases where grafting is unnecessary or undesired.

V.4. Comparative Analysis of the Two Studies

The two clinical studies presented in this thesis—RIE vs. HS and VSRF vs. DDMF—were conducted at distinct surgical stages but share a unified biological and procedural foundation. Both techniques apply the principle of autogenous, graftless soft tissue augmentation using rolled or tunneled mucosal flaps performed under magnification. Despite their timing differences, the methods are conceptually linked by their reliance on native tissue manipulation, microsurgical execution, and a common goal of peri-implant phenotype optimization.

From a biological standpoint, both RIE and VSRF were designed to increase or preserve vestibular MT and KMW using site-specific mucosa, without introducing connective tissue grafts or biomaterials. In both cases, partial-thickness dissection and de-epithelialization formed the basis for volume enhancement. These principles are supported by evidence showing that maintaining vascularity and minimizing surgical trauma promotes soft tissue stability and healing (36, 46, 48). Microsurgical protocols, applied consistently in both studies, further enabled precise flap control, improved wound closure, and better stabilization of the rolled tissue.

However, important differences in clinical application must be acknowledged. RIE is applied during implant placement, with the aim of preserving soft tissue volume during the early healing phase. In contrast, VSRF is performed at implant uncovering and is designed to augment existing tissue in preparation for prosthetic emergence. As such, RIE primarily prevents volume loss, whereas VSRF achieves net volume gain. This distinction reflects not only procedural intent but also different anatomical and healing contexts.

The timeframes of observation also differed. The RIE study followed patients for 12 weeks postoperatively, capturing early soft tissue changes and healing behavior. The VSRF study extended to 12 months, allowing assessment of tissue maturation and medium-term stability. While both studies demonstrated favorable outcomes, the longer follow-up in the VSRF group provided stronger evidence of sustained phenotype improvement, particularly in MT.

Design-wise, the studies also differed in structure. Study 1 (RIE vs. HS) was a small-scale pilot series with 10 patients and no statistical inference, intended to explore early clinical feasibility. Study 2 (VSRF vs. DDMF), although still descriptive, included 44 implants and used a split-mouth design to minimize interpatient variability. Both studies maintained standardized clinical protocols and outcome measures, allowing qualitative comparison across techniques despite differences in timing and scale.

A further distinction lies in the clinical function of the control groups. HS is a conventional suture-based stabilization method, whereas DDMF is an established full-thickness uncovering technique. Each served as a comparator for the respective rolled flap intervention at that surgical stage, thereby contextualizing the graftless approach within standard practice.

Taken together, these studies illustrate how autogenous, microscope-assisted techniques can be integrated into both the placement and uncovering phases of implant therapy. Although not directly comparable in statistical terms, they represent two ends of a procedural continuum in which soft tissue phenotype can be managed conservatively, stage by stage, without grafting. This comparative framework offers clinicians a broader understanding of how biologically grounded flap designs can be tailored to surgical timing and anatomical conditions, supporting predictable and esthetic soft tissue outcomes across the treatment timeline.

V.5. Clinical Implications and Recommendations

The findings of both clinical studies contribute to a growing body of evidence supporting minimally invasive, graftless strategies for peri-implant soft tissue management. By applying autogenous, microscope-assisted flap designs at two distinct surgical stages, the RIE and VSRF

techniques demonstrate how native tissue can be manipulated to preserve or enhance the mucosal phenotype without the need for connective tissue grafting or biomaterials.

The RIE technique offers a conservative solution at the time of implant placement, particularly in cases where soft tissue volume is present but vulnerable to resorption. Its ability to reduce MT loss during early healing makes it suitable for posterior implants in patients with thin or intermediate biotypes, where additional grafting may be unnecessary or undesired. The absence of a donor site and the short learning curve—when performed under magnification—support its practical value in routine implant placement protocols (35, 43, 55, 58).

Conversely, the VSRF technique addresses phenotype enhancement during second-stage surgery. In clinical scenarios where additional buccal volume or keratinized tissue is desired before prosthetic loading, VSRF provides a graftless alternative to CTG or collagen matrix placement. Its vestibular access, preservation of the papillae, and secure rolled flap design contribute to long-term volume stability and emergence profile development. The data suggest that VSRF is especially well suited to posterior implants with narrow soft tissue zones, where full-thickness flap elevation could compromise the mucosal margin (42-44, 60).

Both techniques also reflect a broader shift toward biologically driven, patient-centered surgical protocols. By avoiding palatal harvesting, reducing surgical trauma, and minimizing postoperative discomfort, they align with principles of minimally invasive care that have become increasingly relevant in implantology (32, 33, 35). Although PROMs were not assessed in the present studies, the procedural characteristics of RIE and VSRF are consistent with reported patient preferences in related investigations.

It is important to note that neither technique is intended to replace conventional grafting in cases of significant soft tissue or bone deficiency. The effectiveness of both RIE and VSRF depends on favorable local anatomy, particularly in terms of existing tissue volume and vestibular depth. Furthermore, successful execution requires familiarity with split-thickness dissection, precise incision placement, and microsurgical wound closure. As such, these techniques should be viewed not as universal solutions, but as specialized tools applicable in select clinical contexts.

For the clinician, the implications are practical: when managing soft tissue at implant placement or uncovering, graftless options exist that reduce morbidity without compromising tissue outcomes. Incorporating techniques like RIE and VSRF may allow for phenotype control while simplifying surgical workflow—provided that the clinician has appropriate training and that case selection criteria are respected.

In sum, both RIE and VSRF expand the surgical repertoire for peri-implant soft tissue augmentation. Their integration into contemporary implant protocols may support improved esthetic predictability, long-term soft tissue stability, and enhanced patient satisfaction, especially when applied judiciously within a biologically favorable treatment environment.

V.6. Limitations and Future Directions

While the findings of this thesis support the use of RIE and VSRF as effective, autogenous soft tissue augmentation techniques, several limitations must be acknowledged. These pertain to study design, sample size, measurement methodology, and the absence of patient-reported outcome measures.

First, both studies were designed as exploratory clinical investigations. The RIE study included ten single implants placed in ten patients, and although outcomes demonstrated consistent trends, the sample size precluded statistical analysis. The VSRF study, while more extensive with 44 adjacent implants in 22 patients, also reported descriptive data only. Without formal hypothesis testing or volumetric imaging, the ability to generalize these results remains limited. Nonetheless, the magnitude and consistency of the observed tissue changes—particularly in MT and KMW—offer clinically meaningful insights that warrant further exploration (29, 35, 43).

Second, follow-up durations varied. The RIE study focused on early healing over 12 weeks, allowing for the assessment of immediate tissue stability but not long-term maintenance. The VSRF study extended to 12 months and demonstrated soft tissue stability over the medium term; however, even this period may not fully capture remodeling dynamics under functional load. Longer-term studies are needed to assess whether these outcomes persist over several years of prosthetic function (42, 44).

Another limitation is the absence of patient-reported outcome measures (PROMs). Given the minimally invasive and graftless nature of both RIE and VSRF, it is reasonable to expect benefits in terms of postoperative discomfort, healing experience, and satisfaction. While the literature supports this expectation in similar graftless protocols (32, 35), formal PROM data were not collected in either study. A recent systematic review by Stefanini et al. (80) underscored the importance of including PROMs in clinical studies on soft tissue augmentation, highlighting outcomes such as pain, esthetic satisfaction, and quality of life as critical to comprehensive evaluation. Thus, future research should integrate standardized PROM instruments to assess the subjective impact of these techniques.

Additionally, both studies were performed by a single experienced operator who also conducted outcome measurements. While this ensured procedural consistency, it introduces potential bias.

Blinded evaluation and multi-operator designs may enhance objectivity in future trials. Furthermore, the inclusion of quantitative volumetric assessment tools, such as digital intraoral scanning, 3D soft tissue modeling, or ultrasonography, would improve measurement precision and enable longitudinal tracking of mucosal volume changes.

It should also be noted that the techniques investigated are not universally applicable. Both RIE and VSRF require a minimum amount of existing soft tissue and vestibular depth. Their success depends on favorable local anatomy, and their indications are best limited to phenotype enhancement rather than correction of severe deficiencies. Their reproducibility outside of ideal anatomical conditions, or when performed by less experienced operators, remains to be determined (22, 23, 29, 32, 33, 60).

Future studies should therefore aim to address these limitations through randomized controlled trial designs with larger and more diverse patient populations, objective imaging tools, long-term follow-up, and integration of PROMs. Comparative studies evaluating these techniques against CTG, collagen matrices, or other biomaterials may also help define their place within the broader armamentarium of peri-implant soft tissue management.

VI. CONCLUSIONS

Based on the presented studies, we draw the following conclusions, which we consider as the new scientific findings of the thesis:

1. The Roll-In Envelope (RIE) technique, applied during implant placement, was shown to reduce buccal soft tissue volume loss during early healing compared to the conventional Holding Suture (HS) method, offering a graftless alternative for phenotype preservation in posterior single-implant sites.
2. The Vestibular Split Rolling Flap (VSRF), applied during second-stage surgery, produced clinically stable increases in both mucosal thickness and keratinized mucosal width over a 12-month follow-up, exceeding the outcomes of the Double Door Mucoperiosteal Flap (DDMF) in adjacent posterior implants.
3. When used in anatomically favorable conditions, both techniques achieved their intended outcomes—soft tissue preservation (RIE) and enhancement (VSRF)—without the use of grafts or biomaterials, and without complications.
4. These findings support the application of rolled, autogenous flap designs as stage-specific, microsurgically executed alternatives to grafting, within a minimally invasive treatment approach for peri-implant soft tissue management.

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APPENDIX