RESEARCH PAPER

Soft Tissue Augmentation by Xenogeneic Collagen Matrix Versus Subepithelial Connective Tissue Graft Around Early Implant Placement in Maxillary Esthetic Zone

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Received: 10th Aug, 2025; Revised: 112th Sep 2025; Accepted: 14th Nov, 2025; Available Online: 30th Nov, 2025

ABSTRACT

Background: In the maxillary esthetic zone, soft tissue augmentation is essential for successful aesthetic outcomes surrounding implants. The gold standard(subepithelial connective tissue grafts (SCTG)) entail donor site morbidity. An alternative that is less invasive is provided by xenogeneic collagen matrices (XCM). In order to improve soft tissue, this study compares SCTG with XCM in early implant placement.

Objective: "This study aims to compare and evaluate the clinical results of soft tissue augmentation using a subepithelial connective tissue graft (SCTG) versus xenogeneic collagen matrix (XCM) when done in association with early implant placement in the anterior maxillary esthetic region.

Methods: A randomized controlled clinical trial was conducted on patients who needed to have one of their anterior maxillary teeth replaced.Two groups of twenty participants were randomly assigned:Group A received soft tissue augmentation utilizing a subepithelial connective tissue graft (SCTG) taken from the palate , while Group B received a xenogeneic collagen matrix (XCM). Both augmentation treatments were carried out eight weeks after tooth extraction, and they were done concurrently with early implant placement. The thickness of the soft tissue around the implant, the width of the keratinized mucosa are the primary parameters.

"**Results**:"The peri-implant soft tissue thickness and keratinized tissue width were significantly improved by the subepithelial connective tissue graft and the xenogeneic collagen matrix. Soft tissue thickness were somewhat better for the SCTG group, but these changes were not statistically significant. On the other hand, patients who received XCM reported less postoperative discomfort and morbidity. Conclusion: "For soft tissue augmentation related to early implant placement in the maxillary esthetic region, the xenogeneic collagen matrix offers a viable and minimally invasive alternative to subepithelial connective tissue grafts. Even though SCTG is still the gold standard for attaining superior soft tissue than XCM, it shows similar clinical efficacy and has the benefit of lower patient morbidity. These results provide validity to the idea that, in carefully chosen situations, XCM might be a good substitute.

Conclusion: Both SCTG and XCM show clinical improvement in soft tissue thickness and keratinized tissue width around early implant placement.

Keywords: Thin biotype, XCM, Subepithelial connective tissue graft, esthetic zone,early implant placement.

How to cite this article: Ismail MO, Abdelmonaem M, Khalil AA. Soft Tissue Augmentation by Xenogeneic Collagen Matrix Versus Subepithelial Connective Tissue Graft Around Early Implant Placement in Maxillary Esthetic Zone. Int J Drug Deliv Technol. 2025;15(4): 1994-2001, DOI: 10.25258/ijddt.15.4.52

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

One of the main goals of implant dentistry is to achieve excellent aesthetic standards in the anterior maxilla, which are primarily determined by the volume and shape of the soft tissue around the implant. Because of their consistent results in promoting mucosal thickness and guaranteeing tissue stability, subepithelial connective tissue grafts (SCTG) are commonly recognized as the standard for soft tissue augmentation. However, there are disadvantages to the SCTG procedure, such as longer recovery times, discomfort for patients, and restricted availability of donor sites. In order to reduce patient morbidity and simplify the surgical process, xenogeneic collagen matrices (XCM) have been developed as a less invasive substitute.[1]

In the anterior maxillary region, where aesthetics are crucial, the existence of a thin gingival biotype presents significant difficulties for implant therapy. A prominent gingival scallop, a thin facial bone wall, and soft tissue thickness of less than 1.5 mm are typical characteristics of this phenotype. Following implant placement, these anatomical characteristics are highly associated with greater chances of soft tissue recession, minimal bone remodeling, and less than ideal aesthetic results. Reduced soft tissue volume, according to clinical evidence, makes the peri-implant area more susceptible to stress from

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mechanical forces and surgical procedures, which may jeopardize the stability of peri-implant tissues and the concealment of restorative components.[2]

The advantages of both immediate and delayed implant placement are balanced by the strategic use of early implant placement, which usually takes place 4 to 8 weeks after tooth extraction. This time frame makes it possible for early bone remodeling to stabilize and soft tissue closure to occur, which improves the environment for implant site maintenance. In addition to promoting soft tissue recovery, the method lowers infection risk and offers more control over implant placement, especially in the esthetic zone. According to studies, early implant placement frequently yields better results than immediate implant placement and is linked to good survival rates and predictable aesthetic outcomes. [3]

Preventive or concurrent soft tissue augmentation is frequently necessary for the treatment of individuals with a thin gingival biotype in order to increase tissue volume and improve resistance to both mechanical and inflammatory stress. Gingival recession around implants or prosthetic restorations can be reduced by thickening the peri-implant soft tissues with techniques like subepithelial connective tissue grafts (SCTG) or the use of xenogeneic collagen matrices (XCM). According to clinical studies, thickening the soft tissue in thin biotype cases improves vascularization, long-term stability, and patient satisfaction, especially in places that are important for appearance, such as the anterior maxilla.[4]

The efficacy of xenogeneic collagen matrices (XCM) compared with subepithelial connective tissue grafts (SCTG) has been the focus of several recent investigations. A randomized controlled trial demonstrated that the application of a xenogeneic collagen scaffold for simultaneous soft-tissue augmentation during implant placement resulted in significant volumetric improvements, surpassing those observed in non-augmented sites.[5] These findings underscore the potential of XCM to support ridge preservation during the early stages of healing. Nevertheless, despite these promising results, the comparative effectiveness of XCM and SCTG has not been comprehensively elucidated particularly in the context of early implant placement within the maxillary esthetic zone. Accordingly, the present study aims to evaluate and compare the clinical outcomes of early implant placement combined with soft-tissue augmentation using XCM and SCTG in this critical region.

2. PATIENTS AND METHODS

The Institutional Ethics Committee approved this study, and participants gave their informed written consent before beginning the study.The research was agreed by the research ethics committee of the Faculty of Dentistry-XXXX University

2.1.1. Sample Size Calculation and Randomization

Following a power calculation with G Power 3.19.2 software, the necessary number of patients in each group was established. The effect size was computed using data from previous studies . This produced a minimal sample size of 20 patients to give 80% power at the 5% significance level, with GT as the primary metric. Thus, 20 patients with non-restorable maxillary teeth in the esthetic zone participated in this study.

1.2. selected subjects

All patients were recruited from the outpatient clinic of Minia University Faculty of Dentistry, Oral Medicine, Oral Diagnosis, and Periodontology Department.Using a flip coin, patients were randomly assigned to one of two groups: Ten patients in Group A (early implant placement plus connective tissue graft) Ten patients in Group B (early implant placement plus XCM)Ten Patients.

2. Inclusion Criteria

Thin tissue biotype, 25–55 years old, and systemically healthy were the selected patients of both sexes. Trans-gingival periodontal examinations were conducted at the mesiolabial and distolabial line angles in addition to the midlabial, 2, 4, and 6 mm apical to the gingival margin.[6] (Fig. 1a).

3. Exclusion Criteria

Patients with parafunctional habits or periodontitis, smokers, and pregnant women were excluded.

• Pre-treatment Assessment

Every participant went through a comprehensive first assessment. Interocclusal space was performed after standardized intraoral photos and diagnostic study casts were acquired. The mesio-distal and palato-buccal dimensions of the teeth were measured clinically (fig. 1c, d). Transgingival probing was used to determine the gingival biotype at the intended implant site at six specific locations. A UNC-15 periodontal probe was used to assess periodontal health, and the width of keratinized gingiva was calculated as the distance between the gingival margin and the mucogingival junction. To make sure they were suitable for treatment, each participant underwent a thorough clinical evaluation. To maintain the integrity of the buccal bone, non-restorable teeth were extracted atraumatically using periotomes (fig. 1b). Patients received thorough oral hygiene advice in addition to full-mouth scaling and root planing. Patients were re-examined eight weeks later to confirm a healthy, infection-free site before proceeding to the surgical phase.

•Eight weeks after tooth extraction, cone-beam computed tomography (CBCT) scans were acquired to guide implant planning, including the selection of implant dimensions and evaluation of the alveolar crest. Patients rinsed with 0.2% chlorhexidine solution for one minute on the day of surgery, and 4% articaine with 1:100,000 epinephrine was used to administer local anesthesia via buccal and palatal infiltration. •A No. 15C scalpel was used to make a crestal intrasulcular incision. A full-thickness mucoperiosteal flap was then raised, primarily on the buccal side to facilitate soft tissue grafting and less on the palatal side. In accordance with the manufacturer's instructions, osteotomy was carried out using subsequent drills, and a parallel pin was used to confirm correct alignment. Figure 2 shows that the implant was positioned approximately 0.5–1 mm apical to the alveolar ridge crest. A graft was placed on the buccal pouch, and a cover screw was attached before flap closure

and suturing. •A healing collar was positioned three months after surgery to aid with soft tissue contouring. Either a straight or angled abutment was then placed. After that, an open-tray impression was made in order to fabricate the final prosthesis. Patients were followed up at three, six, nine, and twelve months after implant placement.

•Control Group – Subepithelial Connective Tissue Graft (SCTG) •A subepithelial connective tissue graft was taken from the palate with a single incision for individuals in the control group. A 15C scalpel and Orban knife were used to cut the graft, which had a thickness of around 1.5 to 2 mm, to fit the buccolingual and mesio-distal measurements of the implant site. After that, absorbable crisscross sutures were used to secure it in the recipient area and maintain stability

•Study Group – Mucoderm XCM Application In the study group, Mucoderm, a porcine-derived collagen matrix, was tailored to fit the dimensions of the recipient site. Before being put into a buccal pouch that had been created, the matrix was soaked in sterile saline for 20 minutes to improve its flexibility. After stabilizing it with stitches, the surgery was finished by repositioning and suturing the mucoperiosteal flap.

• Clinical Assessment

•Gingival Thickness (GT) and Keratinized Tissue Width (KTW) were measured at baseline and then again at three, six, nine, and twelve months. To guarantee precise repeatability of the measurement sites, a standardized acrylic stent (Acrostone Acrylic Material - Cold Cure and Acrostone Co., Ltd. Cairo, Egypt) with a thickness of 1 mm was created for each patient prior to surgery. (Table 2). •Modified Plaque Index (MPI), Modified Gingival Index (MGI), and Probing Depth (PD) were assessed at 3, 6, 9, and 12 months.

• Radiographic Assessment

•CBCT was performed at baseline and 3,6,9,12 months

• Crestal Bone Loss

Two horizontal parallel lines, one from the implant platform and the other from the level of the crestal bone, were used alongside with a standardized, repeatable vertical line in the center of the implant that was taken from the coronal cut in the first premolars and the sagittal cut in the anterior teeth. The crestal bone level has been identified as the distance between the two lines.

• Bone Density

The target was first separated from the backdrop by creating a mask using a single threshold value that was chosen based on the image gradient and local gray level value. In order to separate the implant from the bone, the mask was first drawn and then manually erased layer by layer in at least two orientations, all while adhering to the grayscale threshold, which refers to the grayscale of the various tooth structures and bone. Finally, using the program's "Contour Edit," we smoothed and modified the mask to match the goal border. Each buccal surface's bone density was assessed following threshold separation. The density was then determined using the standard deviation and Hounsfield unit area.alignment with two horizontal tangential lines, one originating from the implant platform and the other from the crestal bone's level. The crestal bone level was defined as the separation between the two lines.

• Statistical Analysis

IBM® SPSS® software (version 26. SPSS Inc., IBM Corporation, Armonk, NY, USA) was used to conduct the statistical analysis. The Shapiro-Wilk test was used to examine the data for normality. The mean and standard deviation are used to display quantitative data. The pre- and postoperative means within the same group were compared using a paired t-test, while the means of two separate groups were compared using an independent t-test. Numbers and percentages are used to express qualitative data. The proportions were compared using the Chi-square/exact test. When the p-value was less than 0.05, it was deemed statistically significant, and when it was less than 0.001, it was deemed extremely statistically significant.

RESULTS

Demographics and Data Analysis

A total of twenty patients participated in the study, with an equal distribution of males and females (50% each). the SCTG arm included 40% males and 60% females, while the Mucoderm® arm comprised 60% males and 40% females, with no significant difference in sex distribution ($p = 0.328$). Participant age ranged from 27–53 years; mean age was 41.30 ± 8.91 years in SCTG and 38.80 ± 8.32 years in Mucoderm®, yielding an overall study mean of 40.05 ± 8.49 years and no significant between-group difference ($p = 0.525$). Data were analyzed using SPSS version 26, applying appropriate statistical tests including the Shapiro-Wilk test, paired and independent t-tests, Chi-square test, Friedman test, and Wilcoxon signed-rank test. The significance threshold was set at $p < 0.05$.

The transition from a thin gingival phenotype at screening (<1.5 mm) to surgical baseline means exceeding 2 mm in both groups (SCTG: 3.11 ± 0.26 mm; Mucoderm®: 2.59 ± 0.19 mm) is plausibly attributable to a combination of biological maturation over the 8-week post-extraction interval and graft size at time of surgery, Early soft-tissue remodelling—characterised by fibroblast proliferation, collagen deposition, and resolution of oedema—would be expected to increase mucosal thickness. Following augmentation, gingival thickness remodelled towards a common steady state of approximately 2.1 mm at 12 months in both groups. The SCTG arm exhibited a larger immediate volume that underwent predictable early contraction and biological normalisation, whereas the Mucoderm® arm demonstrated incremental gains as the collagen matrix integrated and was replaced by host connective tissue. The net effect was convergence at one year, with both modalities maintaining values above the thin-biotype threshold and no between-group difference at endpoint.in contrast, keratinized tissue width (KTW) increased in both groups (SCTG: $3.20 \pm 0.65 \rightarrow 4.07 \pm 0.57$ mm; Mucoderm®: $2.78 \pm 0.85 \rightarrow 3.74 \pm 0.89$ mm), where SCTG showed an early peak at 3 months (4.82 ± 0.57 mm) followed by partial regression, while Mucoderm® exhibited steady gains—leaving both groups above baseline and without a significant intergroup difference at 12

months.By the end of the observation period, both groups showed improved KTW, but SCTG started higher and peaked early, while Mucoderm built more gradually and finished more stable.

Across follow-up, Modified Gingival Index (MGI) improved in both groups with no between-group differences at any time point ($p > 0.05$); inflammation decreased progressively, with SCTG reaching 100% normal MGI at 12 months and Mucoderm® 90%. Similarly, Modified Plaque Index (MPI) declined significantly over time in both cohorts with no intergroup differences ($p > 0.05$); although Mucoderm® showed a faster initial improvement, both groups achieved near-complete plaque control by 12 months (SCTG 100% plaque-free; Mucoderm® 90%), demonstrating no meaningful differences in peri-implant mucosal health over 12 months.

Bone Density A continuous and statistically significant increase in bone density was observed across all time points, from 574.68 ± 97.83 HU at baseline to 1942.65 ± 356.52 HU at 12 months ($p < 0.01$), reflecting progressive bone maturation and remodeling. The Mucoderm group demonstrated a steady and significant increase in bone density, rising from 643.48 HU at baseline to 2227.48 HU at 12 months. Each time point showed a statistically significant increase ($p \leq 0.007$), confirming a strong positive trend in osseous integration. Notably, the bone density values at 12 months were slightly higher than the SCTG group, although intergroup comparisons would be needed to confirm statistical significance.At 12 months, bone density was significantly higher in the Mucoderm group than in the SCTG group ($p = 0.049$). Both groups demonstrated significant increases over time ($p < 0.001$), with overall group differences also being significant ($p < 0.001$). However, the time-course of change did not differ significantly between the groups ($p = 0.563$).

Crestal Bone Level There was a consistent decline in crestal bone level from baseline (0.00 mm) to -1.19 ± 0.12 mm at the 12-month mark. The reduction was statistically significant at all evaluated intervals ($p = 0.005$), indicating ongoing peri-implant bone remodeling. The Mucoderm group showed a downward trend, with crestal bone levels decreasing from 0.00 mm to -1.15 mm by 12 months. The drop between 3 and 6 months was not statistically significant ($p = 0.203$), indicating a possible temporary stabilization or variability in the remodeling process. However, all other intervals showed statistically significant changes, confirming progressive crestal bone loss over the year. No statistically significant differences in crestal bone level were found between the groups at any time point ($p > 0.05$). Both groups exhibited consistent bone loss over time ($p < 0.001$), with no significant effects of group or group-time interaction, suggesting comparable long-term resorption patterns.

Discussion

Although implant survival and function remain fundamental metrics for success, increasing attention is being directed toward esthetic outcomes, which play a crucial role in patient satisfaction. Esthetic complications are broadly classified into pink-tissue and white-tissue concerns. Pink-tissue issues include mucosal recession, asymmetry, loss of interdental papillae, and mucosal discoloration, while white-tissue problems involve the crown's morphology, texture, and color.[7] While such complications do not typically compromise osseointegration, they can negatively affect the perceived esthetic quality of the restoration.

Traditional criteria for implant success, such as those proposed byBuser et al., primarily focus on biological and mechanical parameters (e.g., absence of pain, mobility, or peri-implant radiolucency).[8] However, these parameters may not adequately reflect outcomes in esthetically sensitive areas, particularly the anterior maxilla, where soft tissue integration and appearance are paramount. [9, 10]

One of the prominent esthetic challenges is buccal soft tissue dehiscence (BSTD), which can detract from the natural appearance of the peri-implant mucosa. Sanz-Martín et al. [1] identified thin gingival biotype and buccal implant placement as key predisposing factors. The application of connective tissue grafts (CTGs) has been shown to mitigate the incidence of BSTD and enhance soft tissue outcomes.

Early implant placement (EIP)—typically performed 4 to 8 weeks following tooth extraction—has been associated with improved preservation of the alveolar ridge and enhanced soft tissue predictability.[11-13] This timing minimizes post-extraction buccal bone resorption and permits more controlled implant positioning. While EIP helps retain keratinized mucosa, significant gains in keratinized tissue width (KTW) often require adjunctive soft tissue augmentation.[14]

In a systematic review, Ickroth et al.[13] compared early implant placement (EIP) to immediate implant placement (IIP) in the esthetic zone. Their findings suggested that EIP yielded more favorable soft-tissue contours and maintained crestal bone stability more effectively, particularly in cases where the buccal bone remained intact. These results further support EIP as a reliable strategy for achieving esthetic predictability.[13] A key benefit of early implant placement is the potential for precise three-dimensional positioning, which is essential in regions with high esthetic demands. This approach also mitigates the infection risks commonly linked to immediate implant placement and facilitates pre-implant soft-tissue preparation. Compared to delayed implantation, early placement better preserves the alveolar ridge dimensions.

Despite these advantages, achieving optimal esthetic outcomes often requires simultaneous soft tissue augmentation. The most commonly employed techniques include subepithelial connective tissue grafts (SCTG) and xenogeneic collagen matrices (XCM). Both methods aim to improve the quality of peri-implant soft tissues, enhance the emergence profile, and contribute to long-term tissue stability. Soft tissue augmentation is widely recognized as essential for long-term esthetic success. Autogenous subepithelial CTGs are considered the gold standard, offering predictable outcomes in terms of tissue volume and keratinization.[15] Nevertheless, the associated donor site morbidity has prompted interest in alternative materials.

Xenogeneic collagen matrices (XCMs), such as Mucoderm®, have emerged as viable substitutes, offering reduced morbidity and acceptable clinical outcomes .[16]
This study investigated the clinical efficacy of SCTG and Mucoderm® for soft tissue augmentation around implants placed in the anterior maxilla over a 12-month follow-up. Parameters evaluated included gingival thickness, KTW, modified gingival index (MGI), probing depth (PD), modified plaque index (MPI), bone density, and crestal bone level (CBL). When evaluating the two modalities for soft tissue augmentation, At baseline, the SCTG exhibited significantly greater gingival thickness (3.11 ± 0.26 mm) compared to the Mucoderm® group (2.59 ± 0.19 mm). The SCTG group experienced more rapid early tissue remodeling and volume reduction, whereas Mucoderm® demonstrated a gradual but continuous increase in volume. By 12 months, both groups achieved similar gingival thickness, suggesting comparable long-term outcomes. These findings are consistent with those reported by De Angelis et al. [17], who observed greater initial volume with SCTG but similar results between SCTG and XCMs at one year. Additional studies by Schmitt et al. [14], Barakat et al.[18], and Cieślik-Wegemund et al.[19] have likewise confirmed the clinical utility of Mucoderm® in enhancing soft-tissue dimensions. A similar pattern was observed in keratinized tissue width, SCTG produced an early peak in KTW, followed by a gradual reduction over time. Conversely, Mucoderm® demonstrated a progressive increase in KTW throughout the observation period. While SCTG exhibited significantly higher KTW at the 3- and 6-month evaluations, this difference was no longer statistically significant at 12 months, indicating convergence of outcomes. These results are in line with previous findings from Barakat et al. [18] and Cairo et al. [20], which underscore the long-term efficacy of Mucoderm® despite slower initial gains.
Over the 12-month follow-up, both SCTG and Mucoderm® were associated with significant improvements in the Modified Gingival Index (MGI), and no statistically significant intergroup differences were observed at any evaluation point. Resolution of gingival inflammation appeared to occur more rapidly in the SCTG cohort, whereas Mucoderm® was characterized by a more gradual and consistently uniform healing response. The maintenance of favorable peri-implant mucosal conditions, as reflected in the stability of MGI values over time, is consistent with previous reports by Barakat et al.^8 and Cieślik-Wegemund et al. [19], all of which underscore the biocompatibility of both grafting materials in supporting peri-implant soft tissue health. In the early postoperative period, both groups exhibited a transient rise in probing depth at the 3-month assessment, a change that can be attributed to short-term surgical and healing dynamics. Subsequently, the measurements showed a progressive decline, reaching a stable mean of approximately 2.00 mm at 12 months. Although a statistically significant difference was identified between the groups at the 6-month interval, this discrepancy was no longer evident at later follow-ups. These patterns are consistent with the findings of De Angelis et al. [17] who likewise reported stable peri-implant tissue conditions following augmentation with either SCTG or Mucoderm®.

CONCLUSION

When performed in the anterior maxilla, early implant placement—combined with careful planning and adjunctive soft tissue augmentation—can achieve predictable clinical results with favorable esthetic outcomes. Within the limitations of the present study, both subepithelial connective tissue grafts (SCTG) and the xenogeneic collagen matrix Mucoderm® proved effective for enhancing peri-implant soft tissues in the esthetic zone.
SCTG continues to be regarded as the gold standard for peri-implant soft tissue enhancement due to its dependable outcomes in maintaining tissue volume and achieving esthetic integration. However, the need for harvesting autogenous grafts introduces an additional surgical site, which can increase patient morbidity and discomfort. Alternatively, XCM offers a less invasive option by eliminating the requirement for donor site surgery, while still promoting effective soft tissue regeneration and volume preservation. Overall, both grafting modalities successfully maintained peri-implant soft and hard tissue health in early implant placement, with comparable long-term clinical performance. Mucoderm® presents a promising option that balances surgical simplicity, minimized morbidity, and satisfactory esthetic outcomes.

LIMITATIONS AND RECOMMENDATIONS

Conducting larger-scale, multicenter trials is essential to confirm the generalizability of these results across varied patient populations and clinical settings. Studies with longer follow-up durations beyond one year are needed to determine the durability and stability of both soft and hard tissue outcomes over time. The integration of patient-reported outcome measures (PROMs) is important to provide insight into patient comfort, aesthetic satisfaction, and overall quality of life following treatment. Employing advanced digital technologies, such as 3D volumetric imaging or intraoral optical scanning, can enhance the accuracy and reliability of soft tissue assessments. Further histological research is recommended to investigate the biological incorporation and remodeling characteristics of Mucoderm® in comparison with subepithelial connective tissue grafts (SCTG). Economic evaluations, including cost-effectiveness analyses, should be undertaken to determine the financial implications and clinical value of using Mucoderm® as an alternative to autogenous grafting in everyday practice.

ACKNOWLEDGEMENTS

Funding: No funding was received for conducting this study.
Competing interests: The authors have no conflicts of interest to disclose.
The authors have no relevant financial or non-financial interests to disclose.

Consent to participate: All patients provided informed written consent for their participation in the study.
Informed consent: Obtained from all participants.
Approval No The study was approved by Research Ethics Committee; Faculty of Dentistry; Minia University (Protocol No. 505-2021)
Clinical trial registration: ClinicalTrials.gov Identifier NCT07024186.

Table 1. Gingival Thickness (mm): SCTG vs XCM

Time point	SCTG (Mean ± SD)	XCM (Mean ± SD)	P-value
Baseline	1.12 ± 0.28	1.06 ± 0.33	<0.001
3 months	2.53 ± 0.32	2.55 ± 0.20	0.867
6 months	2.26 ± 0.15	2.34 ± 0.12	0.202
9 months	2.14 ± 0.15	2.14 ± 0.11	1.000
12 months	2.05 ± 0.10	2.12 ± 0.12	0.175

Table 2. Keratinized Tissue Width (mm): SCTG vs XCM

Time point	SCTG (Mean ± SD)	XCM (Mean ± SD)	P-value
Baseline	3.20 ± 0.65	2.78 ± 0.85	0.231
3 months	4.82 ± 0.57	3.23 ± 0.88	<0.001
6 months	4.55 ± 0.57	3.33 ± 0.88	0.002
9 months	4.27 ± 0.59	3.46 ± 0.91	0.030
12 months	4.07 ± 0.57	3.14 ± 0.89	0.338

Table 1. Gingival thickness (mm): SCTG vs XCM at baseline and follow-up time points.

Table 3. Probing depth (mm) across follow-up time points for SCTG and XCM groups.

Probing depth Time point	SCTG (Mean ± SD)	XCM (Mean ± SD)	P-value
3 months	3.60 ± 0.52	3.60 ± 0.52	1
6 months	3.10 ± 0.32	2.60 ± 0.52	0018
9 months	2.30 ± 048	2.± 0.91	0065
12 months	2	2	000

Table 4. Bone density (HU) and crestal bone level changes over time for SCTG and XCM groups.

Crestal bone level Time point	SCTG (Mean ± SD)	XCM (Mean ± SD)	P-value
3 months	-0.267 ±0.12	-0.382± 0.24	0.195
6 months	-0.488 ±0.12	-0.473±0.11	0.769
9 months	-0.796± 0.10	-0.846 ± 0.08	0.236
12 months	-1.191±0.12	-1.153± 0.10	0.453
Bone density Time point	SCTG (Mean ± SD)	XCM (Mean ± SD)	P-value
Baseline	574.68 ±97.83	643.48 ±110.01	0.157
3 months	774.52 ± 184.41	879.19± 105.66	0.086
6 months	982.08± 218.91	1128.11± 169.78	0.113
9 months	1343.73 ±316.6	1531.4± 230.5	0.147
12 months	1942.65 ± 356.52	2227.48± 235.94	0.049

Figure 1. Pre-treatment assessment. (a) Measuring gingival thickness (GT) with a UNC-15 probe. (b) Atraumatic extraction using periotomes. (c) Measuring mesiodistal dimensions with a UNC-15 probe. (d) Measuring keratinized tissue width (KT width).
Figure 2. Surgical phase and implant placement. (a) Full-thickness mucoperiosteal flap reflection. (b) Osteotomy site preparation with sequential drilling. (c) Implant placement. (d) Implant positioned 0.5–1.0 mm subcrestal and cover screw attached.
Figure 3. Connective tissue graft (CTG) procedure. (a) Single-incision technique to harvest subepithelial connective tissue graft (SCTG). (b) Harvested SCTG. (c) CTG inserted into the buccal pouch. (d) Suturing.
Figure 4. Collagen matrix application. (a) Mucoderm® membrane. (b) Hydration of Mucoderm®. (c) Mucoderm® placed into the buccal pouch.

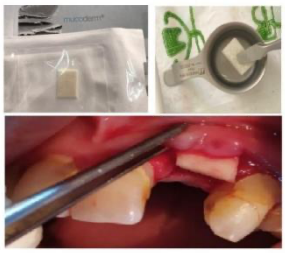


fig4a-mucoderm membrane b-mucoderm hydration c-mucoderm applied on buccal pouch

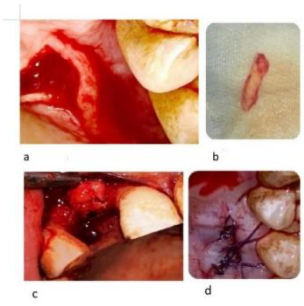


Fig 3 a-single incison technique to harvest SCTG b-CTG c-CTG in buccal pouch d- suturing

Fig 2 a-full thickness mucoperiosteal flap reflection b-preparation of osteotomy by subsequent drilling c-implant placement d-implant placed 0.5:1mm subcrestal and cover screw attached

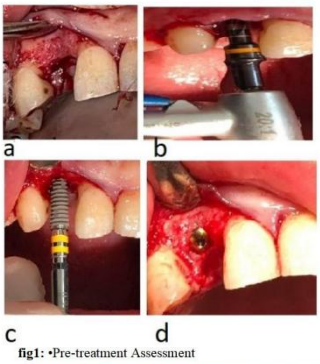
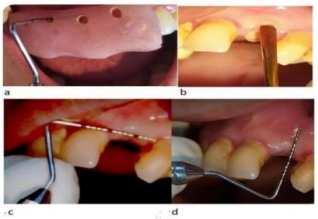


fig1: •Pre-treatment Assessment



a)measuring GT byUNC15 probe- b)-Atraumatic extraction by periotomes c)-measuring mesiodistal dimensions by UNC15 -d)-measuring KTwidth

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