Original Article

COLLAGEN MATRIX VERSUS FREE GINGIVAL GRAFT FOR AUGMENTATION OF KERATINIZED TISSUE IN MANDIBULAR ANTERIOR TEETH: A COMPARATIVE CLINICAL STUDY

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ABSTRACT

Insufficient width of keratinized gingiva (WKG) leads to clinical attachment loss (CAL) and eventually periodontal destruction. Free gingival graft (FGG) is the gold standard to increase WKG but requires a second surgical site and poor esthetics outcomes. Hence, alternatives like collagen matrix (CM) have been developed. The present study aims to evaluate the efficacy of CM versus FGG in augmenting WKG in the lower anterior. Twenty patients with inadequate WKG were enrolled and allocated into two groups. Group I participants received augmentation of WKG using CM and Group II participants with FGG. Clinical parameters such as probing pocket depth, CAL, WKG, and gingival thickness were recorded at baseline, 3rd month, and 6th month. Plaque score was recorded at baseline and 6th month and wound healing index was recorded at 14th and 21st days. The parameters within the group and between the groups were compared using repeated measures of analysis of variance and independent *t*-test.
The mean WKG of Group I and Group II in 6th month after augmentation was 3.88 ± 0.3 mm and 5.21 ± 1.0 mm, respectively, and the difference was statistically significant (P = 0.001). The mean wound healing index for Group I and Group II measured on 21st day was 5.00 ± 0.1 and 2.50 ± 0.5, respectively, and the difference in the wound healing index was statistically significant (P = 0.001). Both CM and FGG are suitable for increasing the WKG. FGG aided in a marginally greater increase in WKG than CM and healing was better with CM as compared to FGG.

Key words: Collagen matrix, Free gingival autograft, Keratinized gingiva, Mucograft, Soft-tissue augmentation.

Introduction

Keratinized gingiva plays a vital role in maintaining periodontal health by providing a protective barrier against mechanical forces and bacterial invasion [1]. Insufficient keratinized tissue, especially in areas like the mandibular anterior region, can lead to compromised gingival attachment and increased susceptibility to periodontal disease. The lack of sufficient keratinized tissue in these regions can also make it more challenging for patients to maintain proper oral hygiene, as limited space for effective toothbrush placement hinders plaque control. This can indirectly contribute to attachment loss and further periodontal deterioration, emphasizing the importance of adequate keratinized tissue for long-term oral health.

To maintain periodontal health and prevent recession associated with narrowly attached gingiva, mucogingival procedures are indicated [2–5]. Although the free gingival graft (FGG) is considered the gold standard for augmenting keratinized gingiva, it has several drawbacks, including the need for a second surgical site, high morbidity, postoperative bleeding, and poor esthetic outcomes [6, 7]. To address these issues, collagen matrices have been used as an alternative.

The collagen matrix (CM) is a soft-tissue scaffolding material that provides space to promote the growth of fibroblasts and blood vessels. It contains type I and III porcine collagen, which is obtained through standardized and controlled manufacturing processes that do not involve cross-linking or chemical treatment [6, 8]. The matrix is a bi-layered structure, with a low-porosity compact layer and a spongy layer with higher porosity. After application, the pores of varying sizes serve as a matrix for tissue and cell adherence and help stabilize the blood clot [9].

Studies investigating the clinical outcomes of CM for the augmentation of keratinized tissue have shown favorable clinical results [10, 11]. However, most of these studies have been conducted around dental implants [12–16]. Few studies suggest that CM is suitable for augmenting keratinized mucosa with long-term stability [17, 18], while another study reported that FGG leads to a more substantial increase in keratinized gingival width than CM [19]. Since the results remain inconclusive, the present study was undertaken to assess and compare the effectiveness of CM versus FGG for augmenting keratinized gingiva in the mandibular anterior region.

Materials and Methods

This is a double-blinded, comparative clinical study that was approved by the institutional ethics review committee for human subjects and conducted in accordance with the Helsinki Declaration of 1975, as revised in 2000. The study population consisted of patients who presented to the outpatient department with insufficient width of keratinized gingiva (WKG) on the buccal aspect of the mandibular anterior region.

The sample size was calculated based on a study by Rokn *et al*. [18] using G*Power Software Version 3.1 (Universität Düsseldorf in Germany). The calculated sample size was 6 per group. Anticipating a 10% loss to follow-up (0.6), the sample size was increased to 7 per group and was then rounded up to 10 per group.

Both male and female patients aged 18–60 years, with inadequate WKG <2 mm in the lower anterior teeth and Miller's Class I and II recession (both narrow and wide) with an identifiable cementoenamel junction (CEJ), were included. Exclusion criteria included the presence of active caries, restorations, or crowns that obscure the CEJ in the cementum; current smokers or users of other forms of tobacco; individuals with a history of uncontrolled systemic disease; pregnant or lactating women; individuals with a history of prior periodontal surgery; teeth with pathological mobility, severe crowding, or Miller's Class III and IV gingival recession.

After providing written informed consent, the participants were allocated to one of two groups by simple randomization. Group I participants underwent augmentation of keratinized gingiva using the CM Mucograft® Collagen Matrix (Geistlich Pharma AG, Wolhusen, Switzerland), while Group II participants underwent augmentation using FGG. All surgical procedures were performed by a single-blinded examiner, and assessments were conducted by a different, calibrated examiner.

Participants underwent scaling and root planing, and were given oral hygiene instructions. They were recalled after 2 weeks, and those exhibiting satisfactory plaque control (as assessed by a plaque score of 0 or 1) and free of clinical inflammation (as assessed by a bleeding score of 0) were enrolled for augmentation [20, 21].

Plaque scores [22] were recorded at baseline and 6 months postoperatively. Probing pocket depth (PPD), clinical attachment level (CAL), and WKG were recorded using a University of North Carolina (UNC) 15 probe at baseline, 3 months, and 6 months. The wound healing index [23] was recorded on the 14th and 21st days postoperatively. The index uses a scale of 1–5, with 1 being very poor and 5 being excellent, based on the following parameters: tissue color, response to palpation, presence of granulation tissue, characteristics of the incision margins, and presence of suppuration. Gingival thickness (GT) was measured using a 15-size endodontic reamer with a stopper at the 3rd and 6th months postoperatively [22-24].

In both groups, recipient site preparation began with a bilateral mental nerve block using 2% xylocaine with 1:100,000 adrenaline. A horizontal incision was made at the mucogingival junction using a 15C blade. Beneath the incision line, the muscle fibers were severed, and vestibular deepening was performed to create a clean periosteal bed. The proposed recipient site, coronal to the incision (including the interdental papilla and available attached gingiva), was thoroughly de-epithelialized up to the line angles of the adjacent teeth on either side. The site was covered with moist gauze until it received the graft. The dimensions of the recipient site were measured using a tinfoil template, which determined the size of the graft [25] **(Figures 1a, 1b, 2a and 2b)**.


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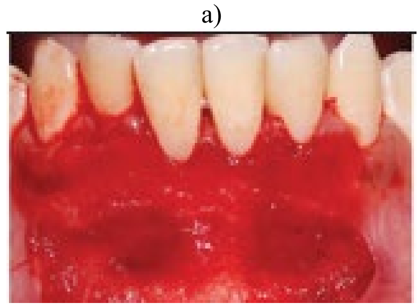
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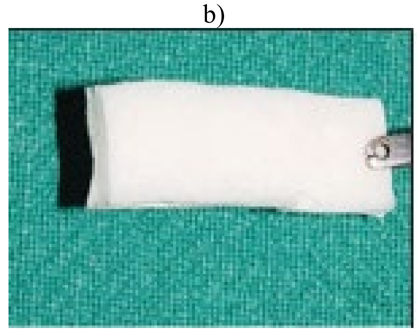
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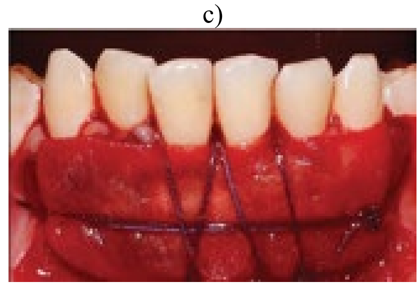
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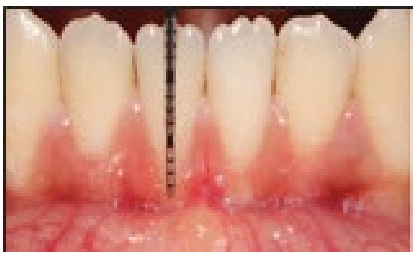
Figure 1. Surgical technique for Group I: (a) COLLAGEN MATRIX – Preoperative; (b) Horizontal incision given, vestibular deepening done and interdental papilla de-epithelized; (c) Collagen matrix trimmed; (d) Collagen matrix sutured onto recipient site; (e) 6th month postoperative image



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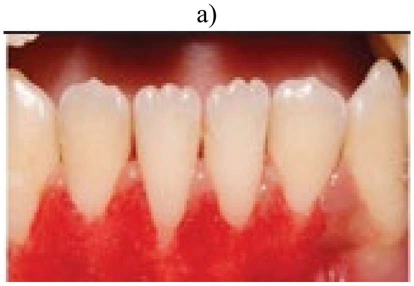

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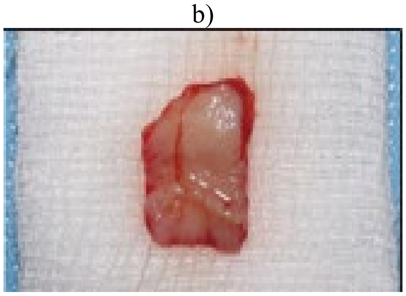

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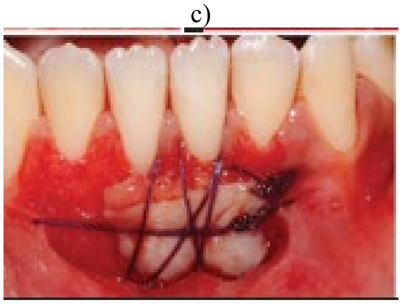

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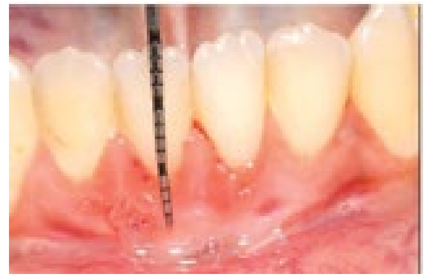

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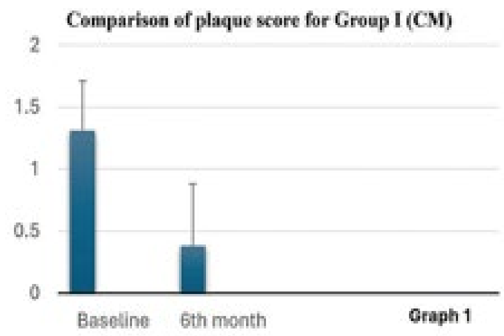
In Group I, the CM was trimmed according to the size of the template and placed directly over the recipient site. Blood was allowed to soak into the matrix to form an initial stable clot, and it was sutured using 3-0 Vicryl® (ALCRYL 910®). The site was then covered with a surgical dressing (COE-PAKT) [26] **(Figures 1c-1e)**. In most cases, no attempt was made to obtain root coverage, as the primary aim was to increase the width of keratinized tissue.

In Group II, the FGG was harvested 3 mm apical to the marginal gingiva, extending from the mesial of the first molar to the distal of the canine, after anesthetizing the area with a greater palatine nerve block. The adipose tissue was removed, and the graft was trimmed to a thickness of 1.5–2 mm. The graft was sutured using 3-0 Vicryl® (ALCRYL 910®) and covered with a surgical dressing. At the donor site, after achieving complete hemostasis, a palatal stent was placed, and the patient was instructed to keep it in place for a week [25, 26] **(Figures 2c-2e)**.

Postoperative instructions, including refraining from brushing, avoiding hot and spicy foods, ensuring adequate rest, and using mouthwash for plaque control, were provided. Amoxicillin 500 mg was prescribed three times a day for 7 days. A combination of aceclofenac and paracetamol was prescribed as a painkiller for 3 days, twice daily after food. After 2 weeks, patients were recalled for suture removal. The surgical site was irrigated, and patients were instructed to continue postsurgical follow-up. The healing index was recorded at the 14th and 21st days, postoperatively and the other clinical parameters were recorded at the 3rd and 6th months, postoperatively.

Results and Discussion

The mean plaque score measured at baseline and in the 6th month for Group I patients was 1.31 ± 0.48 and 0.38 ± 0.5, respectively **(Figure 3)**. In Group II, the mean plaque score at baseline and in the 6th month was 1.57 ± 0.5 and 0.43 ± 0.6, respectively **(Figure 3)**. There was a significant reduction in plaque score between baseline and the 6th month in both groups (P = 0.001), indicating better maintenance after the procedure. When comparing the mean plaque score in the 6th month between Group I and Group II, it was 0.38 ± 0.5 and 0.43 ± 0.6, respectively, which was not statistically significant (P = 0.800) **(Figure 4)**.



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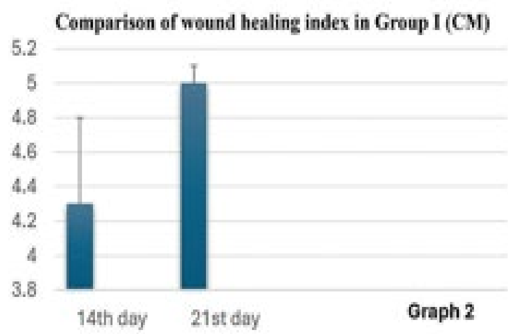

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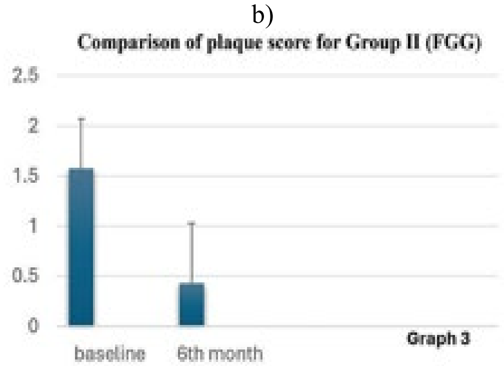

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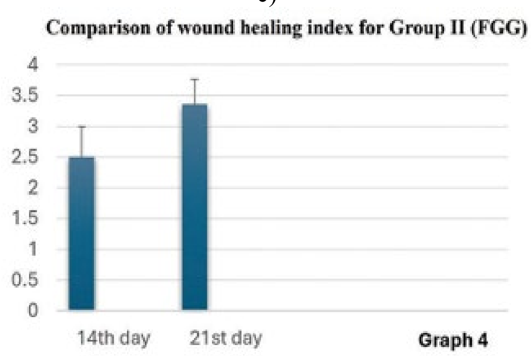

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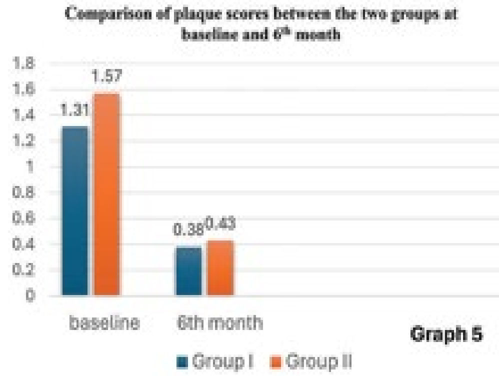
Figure 3. Comparison of plaque scores and wound healing index within the groups



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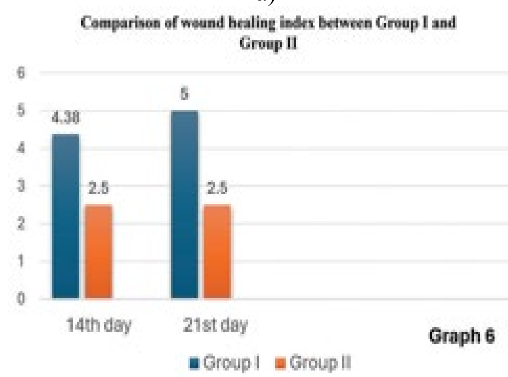

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Figure 4. Comparison of plaque scores and wound healing index between the groups

The mean wound healing index measured on the 14th day was 4.38 ± 0.5, and on the 21st day, it increased to 5.0 ± 0.1 for Group I patients **(Figure 3)**. The mean wound healing index measured on the 14th and 21st days was 2.50 ± 0.5 and 3.36 ± 0.4, respectively, for Group II patients **(Figure 3)**. Both groups exhibited improvement in wound healing as the days progressed (P = 0.001). When comparing the mean wound healing index between the two groups, the CM exhibited better healing than the FGG (P = 0.001) **(Figure 4)**.

The mean PPD for Group I at baseline, 3 months, and 6 months was 1.25 ± 0.4 mm. The mean clinical attachment level (CAL) at baseline, 3 months, and 6 months was 4.06 ± 1.8 mm. There were no significant differences in postoperative PPD and CAL (P > 1.000), as the technique aimed only to augment the WKG, and no root coverage was attempted **(Table 1)**. The mean PPD for Group II at baseline was 1.14 ± 0.3 mm, and at 3 months and 6 months, it was 1.07 ± 0.2 mm. The mean CAL at baseline, 3 months, and 6 months was 3.21 ± 2.1 mm. There were no significant differences in postoperative PPD and CAL for Group II as well (P > 1.000) **(Table 2)**. When comparing PPD and CAL values between the groups at all time points, no changes were observed in PPD and CAL between the groups at any time point (P > 0.05) **(Table 3)**.

Table 1. Comparison of clinical periodontal parameters in Group I (collagen matrix)

Periodontal parameters	Baseline (mm), mean±SD	3 months (mm), mean±SD	6 months (mm), mean±SD	*p value*
PPD	1.25±0.4	1.25±0.4	1.25±0.4	1.000
CAL	4.06±1.8	4.06±1.8	4.06±1.8	1.000
WKG	1.38±0.5	3.87±0.3	3.87±0.3	0.001
GT	1.00±0.0	2.81±0.4	2.81±0.4	0.001

Level of significance set at p > 0.05. PPD – Periodontal pocket depth; CAL – Clinical attachment level; WKG – Width of keratinized gingiva; GT – Gingival thickness; SD – Standard deviation; p – Level of significance

Table 2. Comparison of clinical periodontal parameters in Group II (free gingival graft)

Periodontal parameters	Baseline (mm), mean±SD	3 months (mm), mean±SD	6 months (mm), mean±SD	*p value*
PPD	1.14±0.3	1.07±0.2	1.07±0.2	1.000
CAL	3.21±2.1	3.21±2.1	3.21±2.1	1.000
WKG	1.43±0.5	5.21±1.0	5.21±1.0	0.001
GT	1.07±0.2	2.71±0.4	2.71±0.4	0.001

Level of significance set at p > 0.05. PPD – Periodontal pocket depth; CAL – Clinical attachment level; WKG – Width of keratinized gingiva; GT – Gingival thickness; SD – Standard deviation; p – Level of significance

Table 3. Comparison of clinical periodontal parameters between the groups

Periodontal parameters	Follow up	Group I (mm), mean±SD	Group II (mm), mean±SD	*p* value
PPD	At baseline	1.25±0.4	1.14±0.3	0.481
	3rd month	1.25±0.4	1.07±0.2	0.190
	6th month	1.25±0.4	1.07±0.2	0.190
CAL	At baseline	4.06±1.8	3.21±2.1	0.255
	3rd month	4.06±1.8	3.21±2.1	0.255
	6th month	4.06±1.8	3.21±2.1	0.255
WKG	At baseline	1.38±0.5	1.43±0.5	0.775
	3rd month	3.88±0.3	5.21±1.0	0.001
	6th month	3.88±0.3	5.21±1.0	0.001
GT	At baseline	1.00±0.1	1.07±0.2	0.293
	3rd month	2.81±0.4	2.71±0.4	0.542
	6th month	2.81±0.4	2.71±0.4	0.542

Level of significance set at *p* > 0.05. PPD – Periodontal pocket depth;
CAL – Clinical attachment level; WKG – Width of keratinized gingiva;
GT – Gingival thickness; SD – Standard deviation; *p* – Level of significance

In Group I, the mean WKG measured at baseline was 1.38 ± 0.5 mm, at 3 months was 3.87 ± 0.3 mm, and at 6 months was 3.87 ± 0.3 mm. Comparing baseline to the 3rd month, the increase in WKG was statistically significant (*P* = 0.001) **(Table 1)**. When comparing values between the 3rd and 6th months, no changes were observed. In Group II, the mean WKG measured at baseline was 1.43 ± 0.5 mm, at 3 months was 5.21 ± 1.0 mm, and at 6 months was 5.21 ± 1.0 mm. Comparing the baseline to the 3rd month, the increase in WKG was statistically significant (*P* = 0.001) **(Table 2)**. Again, no changes were observed between the 3rd and 6th months. In both groups, the results obtained in the 3rd month were maintained and stable through the 6th month follow-up. Statistically significant changes were observed between the groups at both the 3rd and 6th months (*P* = 0.001), suggesting that augmentation with FGG resulted in better gain in WKG as compared to CM **(Table 3)**.

In Group I, the mean GT measured at baseline was 1.00 ± 0.0 mm, at 3 months was 2.81 ± 0.4 mm, and at 6 months was 2.81 ± 0.4 mm. Comparing the baseline to the 3rd month, the increase in GT was statistically significant (*P* = 0.001). However, when comparing the values between the 3rd and 6th months, no changes were observed **(Table 1)**. In Group II, the values at baseline, 3 months, and 6 months were 1.07 ± 0.2 mm, 2.71 ± 0.4 mm, and 2.71 ± 0.4 mm, respectively.

Comparing the baseline to the 3rd month, the increase in GT was statistically significant (P = 0.001). Again, when comparing GT between the 3rd and 6th months, no changes were observed **(Table 2)**. In both groups, the results obtained at the 3rd month were stable through the 6th month follow-up. When comparing GT between the groups, no statistically significant difference was observed (P = 0.542) **(Table 3)**.

According to Lang and Löe, keratinized tissue with a width of <2 mm is associated with inflammation and exudate, whereas a width >2 mm is observed to be clinically healthy [27]. Hence, in subjects presenting with inadequate WKG, mucogingival surgical procedures should be considered [2]. FGG is considered the gold standard for augmentation and has a high success rate in terms of increasing WKG and achieving root coverage, but it requires a secondary surgical site [2]. Therefore, an alternative option is to use collagen matrices, which have already been employed in oral wound-healing procedures. The material is engineered to influence the healing cascade and functions similarly to CTG or FGG [28]. Several studies have evaluated the efficacy of CM versus FGG in augmenting keratinized gingiva and have reported that CM appears to be a suitable substitute for FGG in procedures aimed at increasing keratinized tissue around natural teeth [17, 18].

At baseline, clinical parameters such as PPD, CAL, and plaque scores were not statistically significant between the groups, indicating similar periodontal conditions. When comparing plaque scores from baseline to 6 months, both groups exhibited a decrease, suggesting that the patients were effective in maintaining a plaque-free area after augmentation of keratinized gingiva. Kennedy *et al*. reported that adequate keratinized tissue made it easier for patients to maintain oral hygiene [29]. Orsini *et al*. reported that augmentation with a FGG around a fixed prosthesis increased keratinized tissue, thereby favoring plaque control [30]. Sanz *et al*. reported that periodontal status improved after augmentation with collagen matrices [12].

When comparing the wound healing index between the groups, the healing scores with CM were better than with FGG (P = 0.001). Similar results around dental implants were reported by Schmitt *et al*. [15], CM, made of Type I and III collagen, has a compact layer that allows suturing and protection of the graft, as well as a porous layer that promotes blood clot stabilization, cell ingrowth, and early vascularization, thereby accelerating soft-tissue healing [31]. Connective tissue formation was also observed to increase between 3 and 6 weeks, while the remaining collagen network gradually remodels and decreases over time. New blood vessels emerge at the matrix border by the 3rd week, stabilizing over time, while new blood vessels gradually increase in the center [32] Sullivan and Atkins reported angiogenesis around the 10th day in FGG, which would indicate that healing should have been better with FGG [33]. However, in the present study, healing index scores were in favor of CM.

The mean WKG after augmentation at 3 and 6 months showed significant improvement within the groups. Similar results were obtained in studies using FGG and CM around natural teeth and implants [10, 11, 17, 18, 34]. In the present study, augmentation with FGG resulted in a greater gain in keratinized gingiva compared to CM. Huang *et al*. reported an increase in WKG around dental implants with an apical repositioning flap and FGG, as compared to CM [19] Schmitt *et al*. found that FGG appeared to be more stable over time compared to CM [15]. Agudio *et al*. reported that the gingival margin shifted coronally 1 year after augmenting WKG with FGG [35].

CM integrates fibroblasts, epithelial cells, and blood vessels to form three-dimensional structures during the early stages of wound healing, creating new tissue and thereby increasing the width and thickness of keratinized tissue surrounding the gingiva [11]. The increased WKG with FGG compared to Mucograft could be due to a phenomenon known as “bridging” and “creeping attachment,” as reported by Sullivan and Atkins. In this process, collateral circulation occurs from the mesial and distal portions of the graft, aiding in recession coverage and increasing the augmentation of attached gingiva [33].

By the 7th day after grafting, the migrating epithelium completely covers the grafted area. The epithelium and connective tissue establish a relationship similar to that found in attached gingiva, with deep rete pegs and an undulating basement membrane. By the 14th day, complete epithelialization occurs, and the graft develops the morphologic characteristics of the attached gingiva. By day 28, the graft completes full differentiation and becomes indistinguishable from the adjacent tissues [36]

Few studies have previously evaluated GT after augmentation with FGG or CM. Moussa *et al*. reported that augmentation with CM around implants increased GT to levels similar to connective tissue graft [37]. Huang *et al*. reported that the GT at 6 months post-augmentation was significantly higher in the FGG group compared to the CM group [19]. In contrast, Schallhorn *et al*., after augmentation with CM, reported a reduction in GT from 6 mm apical to the marginal gingiva [38]. In the present study, there was an increase in GT at both the 3rd and 6th months post-augmentation in both groups, suggesting that both CM and FGG were effective in increasing GT.

Although FGG resulted in statistically significant greater keratinized tissue, the Mucograft graft offers considerable benefits for addressing complex surgical cases in a single procedure. Its ample availability ensures a sufficient supply of graft material, eliminating the need for limited palatal donor tissue, making it particularly suited for extensive oral rehabilitation. In cases requiring significant augmentation of keratinized gingiva, MG serves as an effective alternative, overcoming the limitations of palatal tissue.

This study highlights a significant increase in the WKG with the use of FGG. In addition, the benefits of reduced tissue morbidity and shorter surgical time associated with CM should be considered in treatment planning [39–42]. However, the study had a limited follow-up period of only 6 months post-operatively. Moreover, it did not assess the amount of shrinkage to be expected with CM, which is important for accurately determining the appropriate graft dimensions when augmenting keratinized mucosa. Further research with a larger sample size and extended follow-up periods, along with measures to address the above-mentioned limitations, is necessary to validate these results.

Conclusion

Both CM and FGG are effective in increasing the WKG. However, it was found that FGG resulted in a greater increase in the keratinized gingival zone compared to CM, while healing was more favorable with CM than with FGG.

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Conflict of interest: None

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Ethics statement: None

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