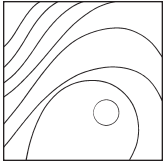


Effect of Connective Tissue Graft Following Immediate Implant Placement on Esthetic Outcomes at Maxillary Central Incisor Sites: A Long-Term Cohort Study



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The aim of this cohort study was to assess the effect of connective tissue graft (CTG) following immediate implant placement (IIP) at maxillary central incisors on esthetic outcomes, buccal bone thickness, soft tissue dimensional alterations, and patient-centered outcomes. Twenty-eight patients treated with IIP at maxillary central incisor sites with approximately 6 ± 4 years in function were divided according to the use of CTG ($n = 17$) or no CTG ($n = 11$). The primary variable of the study was the Pink and White Esthetic Score (PES/WES), evaluated in photographs taken before and after implant placement. The thickness of the buccal bone, midbuccal mucosal level (MBML) changes, and patient satisfaction were assessed and compared between the two groups. The results showed similar PES/WES before IIP between the CTG and no-CTG groups (13.5 ± 3.7 and 12.6 ± 3.2 , respectively). After IIP, the PES/WES value in the CTG group was significantly higher (15 ± 2.5) than in the no-CTG group (12.1 ± 3.1) ($P = .012$). No significant differences in the buccal bone thickness, MBML, or patient satisfaction were observed in CTG and no-CTG groups. This study found that CTG following IIP and socket grafting promoted better esthetic outcomes. *Int J Periodontics Restorative Dentistry* 2022;42:xxx-xxx. doi: 10.11607/prd.5773

Immediate implant placement (IIP) following tooth extraction is a successful treatment alternative with predictable outcomes.^{1,2} Some advantages, such as shortened treatment time and reduced surgical trauma, have made this an attractive treatment modality, especially in the anterior maxilla.^{3,4} However, previous systematic reviews reported an association between IIP and a relatively high frequency of advanced midbuccal mucosa recession (> 1 mm) and compromised esthetic outcomes.⁵⁻⁷

A recent systematic review⁸ including eight studies and 409 implants with 12- to 108-month follow-ups reported a significantly more coronal midbuccal mucosal level (MBML) in sites that received IIP with connective tissue graft (CTG) than sites without CTG. The review also showed that implant sites that received soft tissue graft exhibited less risk ($\times 12$) for advanced recession than sites where no CTG was used. Soft tissue grafts have also been recommended to compensate for postextraction buccal bone loss deficiency by increasing the mucosal thickness.^{9,10}

The maxillary central incisor region is of major importance for esthetics and patient satisfaction.¹¹ In addition, the maxillary central incisor region has its own anatomical features that are different from the

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Table 1 Inclusion and Exclusion Criteria

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> • Healthy adults (≥ 21 years old) exhibiting good oral hygiene • Failing maxillary central incisor site with a healthy corresponding contralateral tooth • Treated with immediate implant placement and socket graft combined or not with a soft tissue graft [Au: A CTG?] • Presence of intact buccal socket wall after tooth extraction • CBCT scan taken after at least 1 year in function 	<ul style="list-style-type: none"> • Presence of soft and/or hard tissue pathology that required a previous surgical procedure (eg, cyst, granuloma) • Crowding and improper tooth alignment in the maxilla • Partial loss of the buccal bone wall after tooth extraction • Presence of any systemic condition or use of drugs that affect bone metabolism • Tobacco abuse (>10 cigarettes/day)

remaining anterior teeth (lateral incisors and canines)^{12,13} and is also a common site for esthetic complications. Recent long-term follow-up studies have indicated a higher frequency of severe midbuccal recession in implants placed at the maxillary central incisor region.^{3,14} To the best of the present authors' knowledge, there is no study in the literature on the use of CTG following IIP that includes only maxillary central incisor sites.

Thus, the aim of this study was to assess at maxillary central incisors the effect of CTG following IIP on esthetic outcomes (Pink and White Esthetic Scores [PES/WES]), buccal bone thickness, soft tissue dimensional alterations, and patient-centered outcomes.

Materials and Methods

Study Design and Sample Population

This retrospective cohort study included 28 patients treated in a private dental office between 2003 and 2018 for the replacement of a

single failing maxillary central incisor. Ethical approval was obtained by the Institutional Review Board for Research Conducted with Human Beings at the State University of Maringá, Brazil (protocol 27928919.9.0000.0104). This study was conducted in accordance with the Declaration of Helsinki, and the manuscript preparation followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines. All patients were treated with IIP at maxillary central incisor sites and met the eligible criteria described in Table 1.

Intervention Procedures

Following local anesthesia, a minimally invasive tooth extraction was performed with periostomes and root elevators. The alveolar socket was carefully inspected for the presence of any pathology, and all granulation tissue was removed. The implant bed was prepared using a surgical guide, and implant placement followed the manufacturer's instructions (Straumann or Nobel Biocare **[Au: Please specify the**

Straumann and Nobel Biocare implants used.]). A conical healing cap

was adapted to the implant, and the gap between the inner aspect of the buccal wall and the implant surface was filled with an anorganic bovine bone graft (Bio-Oss, Geistlich). In some patients, a CTG was harvested from the palate at the premolar region and placed, between the outer surface of the socket and the buccal soft tissue, as a full-thickness envelope to the level of the mucogingival junction and interproximal line angles. Mattress sutures were used to stabilize the CTG at the buccal soft tissues, while cross sutures were placed to stabilize the gingival margin. All surgical procedures were performed by the same periodontist **[Au: If the periodontist is an author of this study, please include their initials here.]** Patients were asked to rinse with chlorhexidine (0.12%) twice daily for 14 days. Antibiotics and analgesics were prescribed. The sutures were removed after 2 to 3 weeks. After 3 months, soft tissue conditioning began with a screw-retained fixed provisional, and the final ceramic crown was placed 2 to 3 months later. Patients

were enrolled in a biannual maintenance program that included oral hygiene instructions, prophylaxis with a rubber cup, and scaling at bleeding sites.

At the final examination (T1; 6 ± 4 years), subjects were divided into one of two groups according to whether the patient received a CTG (CTG group) or not (no-CTG group) following IIP with socket grafting.

Photographic Assessment

Intraoral photographs were taken before implant placement (T0) **[Au: Is T0 before or after tooth extraction?]** and at T1. A D90 digital camera (Nikon) equipped with a 105-mm macrolens and ring flash was used to capture the images. Subsequently, the images were transferred to a computer for different analyses.

Clinical and Radiographic Outcomes

Esthetic scores

The primary outcome was the sum of Pink and White Esthetic Scores (PES/WES), as described by Belser et al.¹⁵ The threshold for clinical acceptance for both PES and WES was set at 6 (scores < 6 were considered unsatisfactory). Intraoral photographs taken at T0 and T1 were randomized using an online tool (random.org), organized in an online formulary (Google Forms), and assessed by four prosthodontists not involved with the treatment. **[Au: If any of these prosthodontists are**

authors of the study, please include their initials here.]

Gingival phenotype and mucosal recession

Gingival phenotype was assessed in photographs taken at T0. The sites were divided into thin, medium or thick phenotype according to the ITI Treatment Guide volume 10.¹⁶

Intraoral photographs taken at T1 were transferred to an open-source software (Image J, National Institutes of Health). To calibrate the software for the measurements, the central incisor width at the coronal third level was measured on the CBCT reconstructions and subsequently overlapped and adjusted to the corresponding location on the clinical photographs. A blinded and calibrated examiner measured the MBML **[Au: If the examiner is an author of this study, please include their initials here.]** Crown height was defined as the distance from the midbuccal gingival/mucosal margin to a reference line crossing the incisal edge of the natural neighboring teeth. This measurement was obtained at the implant and contralateral sites at T1. MBML changes were obtained by subtracting the crown height at the contralateral site from the implant site. A negative value indicated peri-implant mucosal recession.

CBCT scan assessment

Posttreatment CBCT reconstructions (T1) were obtained using the CS 9300 scanner (Carestream Dental) with a field of view of 5 × 5 cm and a voxel size of 0.09. Image reconstruction for visual analysis was

performed using the CS 3D Imaging Software (Carestream). A blinded and calibrated examiner performed all measurements **[Au: If the examiner is an author of this study, please include their initials here.]** Cross-sectional reconstructions were obtained from the central portion of the implant. A 3D implant template provided by the software with the same dimension and brand of the installed implant was inserted and aligned with the implant reconstruction to avoid distortion by metallic artifacts. The buccal bone thickness was measured as the linear distance between the outer surface of the buccal bone and the implant surface, measured at the implant shoulder and 2, 4, and 6 mm below. All measurements were performed perpendicularly to the implant long axis.

Subjective Outcome Questionnaire

All patients received via email a subjective outcome questionnaire (SOQ) regarding their satisfaction with the esthetic outcome. It consisted of five questions, previously described by Boardman et al,¹⁷ each with a 10-point numeric scale ranging from "not satisfied at all" (score of 1) to "completely satisfied" (score of 10) **[Au: Correct?]**

Calibration

Intraobserver error was determined for soft and hard tissue measurements. All variables were assessed

Table 2 Patient and Implant Characteristics

Parameter	CTG (n = 17)	No-CTG (n = 11)
Age, y	55.4 ± 16.5	62.5 ± 13.1
Gender, n (%)		
Male	4 (23.5)	4 (36.4)
Female	13 (76.5)	7 (63.6)
Gingival phenotype, n (%)		
Thin	5 (29.4)	3 (27.3)
Medium	9 (52.9)	4 (36.4)
Thick	3 (17.7)	4 (36.4)
Implant brand, n (%)		
Straumann	15 (78.9)	10 (90.9)
Nobel Active	2 (11.8)	1 (9.1)
Implant diameter, n (%)		
Narrow (3.3 to 3.5 mm)	2 (11.8)	0 (0)
Regular (4.1 to 4.3 mm)	14 (82.3)	6 (54.5)
Wide (4.8 mm)	1 (5.9)	5 (45.5)
Implant length, n (%)		
10 mm	2 (11.8)	1 (9.1)
11 to 12 mm	11 (64.7)	7 (63.6)
13 to 14 mm	4 (23.5)	3 (27.3)
Implant-crown connection, n (%)		
Screw-retained	20 (74.1)	6 (54.5)
Cemented	7 (25.9)	5 (45.5)
Time in function, n (%)		
≤ 4 y	11 (64.7)	1 (9.1)
> 4 y	6 (35.3)	10 (90.9)

CTG = connective tissue graft.
Ages are presented as mean ± SD.

twice in a 24-hour interval. The intra-class correlation coefficient obtained for photographic and CBCT variables were 0.967 and 0.907, respectively.

Statistical Analysis

Means and standard deviations were obtained for all variables. Shapiro-Wilk normality test was

performed. Intergroup comparison of normally distributed variables was done using Student *t* test. Otherwise, nonparametric Mann-Whitney *U* test was used. For analyses over time, paired Student *t* test or Wilcoxon test was used. All statistical analyses were computed with an open-source software (Jamovi, version 1.6). The level of significance was set at 5%.

Results

Patient and implant characteristics are shown in Table 2. The present study included 28 patients: 17 (61%) in the CTG group and 11 in the no-CTG group. Figures 1 and 2 illustrate the two treatment groups and long-term outcomes. No signs of biologic or technical complications were observed in the treated

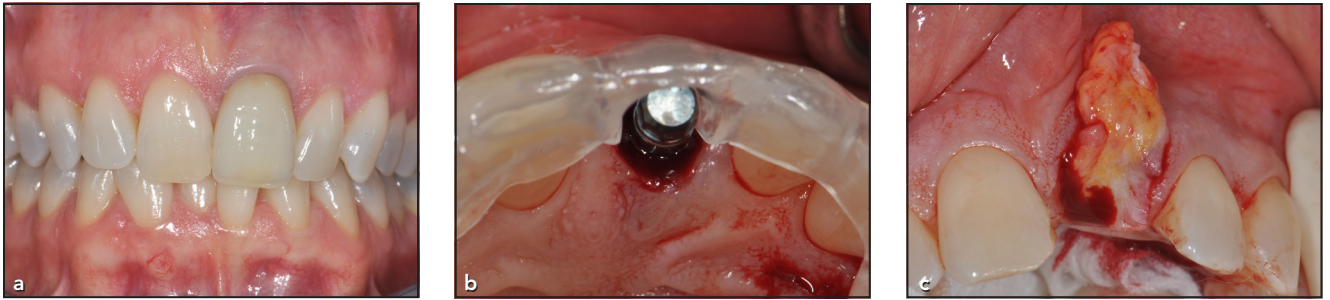
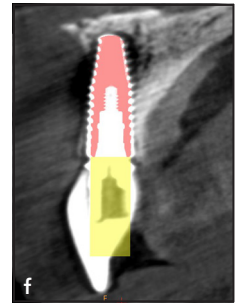
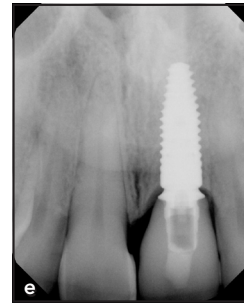


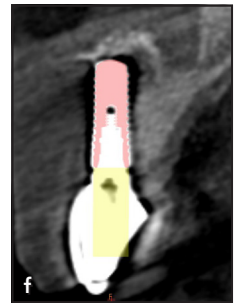
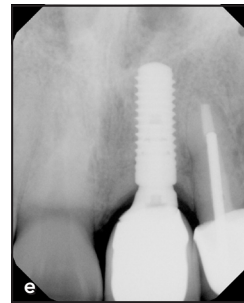
Fig 1 CTG group. (a) A healthy, nonsmoking, 50-year-old woman's maxillary left central incisor was indicated for extraction. She presented with realistic expectations, a medium lip line, and a medium gingival phenotype. (b) Orthodontic treatment was completed 8 months prior tooth extraction. A 4.1 x 12-mm implant was placed in the correct 3D position with the aid of a surgical guide, and the



buccal gap was filled with anorganic bovine bone graft. [Au: Correct?] (c) A CTG was harvested from the palate and buccally positioned. (d) Facial view of the final screw-retained implant crown at the 3-year follow-up, with a stable MBML. (e) The periapical radiographic view shows marginal bone level stability at 3 years. (f) The CBCT cross-sectional reconstruction.



Fig 2 No-CTG group. (a) A healthy, nonsmoking, 42-year-old woman's maxillary left central incisor was indicated for extraction. She presented with realistic expectations, a low lip-line, and a thick gingival phenotype. (b) A 4.1 x 12-mm implant was placed in the correct 3D position with the aid of a surgical guide. (c) The buccal gap was filled with anorganic bovine bone graft [Au: Correct?], and no



CTG graft was used. (d) Facial view of the final implant-supported rehabilitation at the 7-year follow-up, showing an 0.8-mm midbuccal mucosal recession. (e) The periapical radiographic view shows marginal bone level stability at 7 years. (f) The CBCT cross-sectional reconstruction.

Table 3 Mean PES/WES Values Before Implant Placement and at the Final Follow-up [Au: Changes okay?]

	T0			T1		
	CTG	No-CTG	<i>P</i>	CTG	No-CTG	<i>P</i>
PES	7.6 ± 1.6	6.5 ± 1.6	.085	7.3 ± 1.6	6.2 ± 1.7	.083
Mesial papilla	1.8 ± 0.5	1.5 ± 0.6	.123	1.6 ± 0.4	1.3 ± 0.6	.083
Distal papilla	1.8 ± 0.4	1.5 ± 0.4	.011	1.7 ± 0.4	1.3 ± 0.7	.071
Facial mucosa curvature	1.4 ± 0.5	1.2 ± 0.4	.314	1.3 ± 0.5	1 ± 0.5	.164
Facial mucosa level	1.4 ± 0.5	1.1 ± 0.6	.212	1.3 ± 0.6	1.2 ± 0.7	.848
Root convexity/soft tissue color and texture	1.3 ± 0.5	1.2 ± 0.5	.682	1.4 ± 0.5	1.5 ± 0.4	.755
Acceptable (≥ 6), n (%)	15 (88%)	8 (73%)		16 (94%)	8 (73%)	
WES	5.9 ± 2.8	6.1 ± 2.5	.861	7.7 ± 1.7	5.9 ± 2.4	.025
Tooth form	1.4 ± 0.6	1 ± 0.6	.138	1.6 ± 0.3	1 ± 0.6	.002
Tooth volume/outline	1.3 ± 0.5	1 ± 0.5	.114	1.4 ± 0.4	0.9 ± 0.6	.016
Color	0.8 ± 0.7	1.3 ± 0.7	.083	1.5 ± 0.6	1.3 ± 0.7	.630
Surface texture	1.2 ± 0.8	1.3 ± 0.7	.793	1.6 ± 0.4	1.3 ± 0.6	.229
Translucency	1.2 ± 0.7	1.5 ± 0.6	.337	1.6 ± 0.6	1.4 ± 0.7	.307
Acceptable (≥ 6), n (%)	10 (59%)	8 (73%)		16 (94%)	7 (64%)	
PES/WES	13.5 ± 3.7	12.6 ± 3.2	.495	15 ± 2.5	12.1 ± 3.1	.012

T0 = before implant placement [Au: Is T0 before or after tooth extraction?]; T1 = final examination (6 ± 4 years later).

Table 4 Midbuccal Mucosal Level Changes Between the Implant and Tooth Sites at the Final Follow-up [Au: Change okay?]

		Crown height, mm	MBML, mm	<i>P</i>
CTG (n = 17)	Tooth	10.6 ± 1.2	0.1 ± 0.6	.43
	Implant	10.5 ± 1		
No-CTG (n = 11)	Tooth	11.1 ± 1.6	-0.4 ± 1	
	Implant	11.4 ± 1.7		

CTG = connective tissue graft; MBML = midbuccal mucosal level; T1 = final follow-up (6 ± 4 years later).

sites during the maintenance program. PES/WES scores at T0 and T1 are presented in Table 3. At T0, the total PES/WES score was similar between CTG and no-CTG groups (13.5 and 12.6, respectively), except for the distal papilla. However, at T1, the scores were significantly higher in the CTG group than in

the no-CTG group (15 and 12.1, respectively). The main differences were observed in tooth form and tooth volume/outline scores ($P < .05$). Furthermore, the frequency of sites exhibiting PES ≥ 6 following implant treatment was 94% in the CTG group and 73% in the no-CTG group; the corresponding frequen-

cy of sites with WES ≥ 6 were 94% and 64%, respectively.

Photographic measurements are presented in Table 4. The MBML in both groups were similar. In addition, 2 out of 17 sites (12%) in the CTG group exhibited a midbuccal mucosal recession ≥ 0.5 mm while this was exhibited in 4 out of 11 sites

(36%) in the no-CTG group (Fig 3). Only 1 site in the no-CTG group showed advanced midbuccal mucosal recession (≥ 1 mm).

The mean buccal bone wall thickness at T1 is listed in Table 5. The CTG and no-CTG groups presented similar results at the implant shoulder and at 2, 4, and 6 mm below. The overall buccal bone thickness was 1.4 mm (range: 0 to 3.8 mm) in the CTG group and 1 mm (range: 0 to 3.2 mm) in the no-CTG group. No statistically significant differences were found between both groups and different bone levels. No detectable buccal bone wall at any level was observed at two sites (12%) in the CTG group and at four sites (36%) in the no-CTG group.

The patient satisfaction SOQ scores are shown in Table 6. Both groups reported high levels of satisfaction, with an overall mean score of 9.8 in the CTG group and 9.7 in the no-CTG group. The frequency of a score of 10 was 83.5% in the CTG group and was 76.4% in the no-CTG group.

Discussion

The present study assessed the effects of CTG on the esthetic outcomes, midbuccal mucosal stability, buccal bone dimension, and patient satisfaction at a single immediate implant in the central incisor site in 28 patients. The results showed that the use of a CTG following IIP significantly improved the PES/WES outcomes compared to no CTG. There were, however, no differences

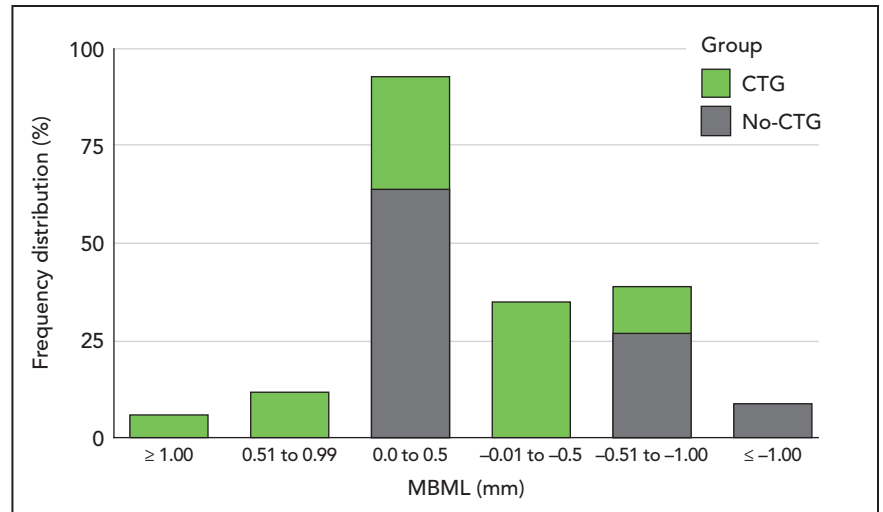


Fig 3 Relative frequency of midbuccal mucosal level (MBML) changes of the CTG and no-CTG groups, determined by comparing implant and contralateral sites at T1.

Table 5 CBCT Analysis of the Buccal Bone Wall Thickness at Four Different Levels from the Implant Shoulder

Distance from the implant shoulder	CTG (n = 17)	No CTG (n = 11)	P
0 mm	1.5 ± 1.1	1.1 ± 1.1	.376
2 mm	1.5 ± 1	1.1 ± 1.2	.284
4 mm	1.3 ± 1	1.1 ± 1.1	.486
6 mm	1.3 ± 1.3	0.9 ± 1	.435

in mucosal recession, buccal bone dimension, or patient satisfaction between the two groups.

In the present investigation, the final WES values were significantly higher in the CTG group than in the no-CTG group. PES scores were also higher in the CTG group than the no-CTG group, but with no statistically significant difference. Several clinical studies observed better esthetic outcomes when CTG was used.^{10,18} In contrast, some randomized clinical trials failed to observe significant differences in soft tissue

esthetics following IIP with or without CTG.^{19–21} A recent meta-analysis also reported no significant differences in PES scores between sites in which a CTG was applied and sites without it.⁸ The difference in findings could be explained by the fact that different teeth in the esthetic area were included in the other studies,^{19–23} while only maxillary central incisors were evaluated in the present study. These findings demonstrate that PES/WES values are influenced by the use of CTG as well as other factors.

Table 6 Patient Satisfaction Regarding the New Implant Tooth and the Peri-implant Soft Tissue Esthetics

Question	CTG (n = 17)	No-CTG (n = 11)
How do you feel about the shape of the new implant tooth?	9.8 ± 0.6	9.6 ± 0.7
How do you feel about the color of the new implant tooth?	9.6 ± 0.9	9.6 ± 0.7
How do you feel about the shape of the gum that is around the new implant tooth?	9.8 ± 0.5	9.8 ± 0.4
How do you feel about the color of the gum that is around the new implant tooth?	9.7 ± 0.6	9.7 ± 0.5
What is your overall satisfaction with the new implant tooth?	9.9 ± 0.2	9.5 ± 1.5
Mean	9.8 ± 0.4	9.7 ± 0.7

Each question was answered on a 10-point numeric scale ranging from “not satisfied at all” (score of 1) to “completely satisfied” (score of 10). **[Au: Correct?]**

The amount of mucosal recession at the implant sites was not significantly different between the two groups. Nevertheless, the frequency of sites with midbuccal recession ≥ 0.5 mm was higher in the no-CTG group (36%) than in the CTG group (12%). This finding is not in agreement with previous studies that reported significantly more mucosal recession at no-CTG sites.^{19,20,23} These differences are likely due to the different methodologies used in the studies to define and measure mucosal recession. In previous studies by Zuiderveld et al,^{20,22} recession was defined as the difference between the soft tissue levels at the implant site before tooth extraction and after implant placement. In the present study, recession was defined as the difference between the mid-buccal mucosal level at the implant site and the gingival margin at the contralateral natural central incisor. It is suggested **[Au: Suggested by whom? Please cite those studies here.]** that the current methodology **[Au: The methodology of**

the present study?] truly reflects marginal soft tissue symmetry and esthetic perception.

The CTG and no-CTG groups exhibited similar buccal bone thickness at the long-term follow-up (1.4 ± 1.1 mm and 1 ± 1.1 mm, respectively). Similar findings were also observed in previous studies.^{18,24} Contrarily, Zuiderveld et al²² reported significantly more buccal bone loss in the CTG group than in the no-CTG group. The authors suggested that the surgical intervention used to place the CTG promoted the bone loss. It appears that CTG has no benefits in maintaining the buccal bone dimension, and other factors (such as grafting of the buccal gap) may play a more important role in the bone dimension.

The findings from the present retrospective study should be interpreted with caution due to the following limitations: a retrospective design, a small sample size in the control group, and different long-term follow-ups. However, a strength of the study is that all surgeries were

performed by the same experienced periodontist, using standardized diagnostic, surgical, and prosthetic procedures, and an esthetic risk assessment was included.¹⁶ Most importantly, only maxillary central incisor sites were included to avoid diluting the results of combined esthetic zone sites in the final data. Other parameters, including the peri-implant phenotype, other anatomic characteristics of the socket site, inclusion criteria, and buccal gap dimension, could have affected the results. The treatment of this area is considered complex, and other treatment options can be considered when approaching a similar situation. For example, a team approach combined with the 10-keys protocol can significantly reduce complications if sequentially followed.^{25,26} **[Au: Changes okay?]**

Conclusions

This retrospective cohort study at maxillary central incisor sites indicat-

ed that placing a CTG after immediate implant insertion promoted better esthetic outcomes (PES/WES). However, the use of CTG failed to significantly influence the amount of mucosal recession, the buccal bone thickness, and patient satisfaction.

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Author contributions:

R.A.L.: Patient treatment; study design; data collection; first, second, and final draft.

D.R.D.: Data analysis and interpretation; first, second, and final draft.

P.W.: Data collection; data analysis; revisions; and final draft.

M.G.A.: Study design; data analysis and interpretation; first, second, and final draft.

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