Treatment of labial soft tissue recession around dental implants in the esthetic zone using guided bone regeneration with mineralized allograft: a retrospective clinical case series

Running Head: Management of implant labial mucosal recession

Keywords: gingival recession, maxillary implants, pericardium membrane, allograft

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Treatment of labial soft tissue recession around dental implants in the esthetic zone using guided bone regeneration with mineralized allograft: a retrospective clinical case series

ABSTRACT

Objectives: Soft tissue augmentation procedures are often performed to correct gingival recesson on the facial aspects of implants in the esthetic zone. This retrospective clinical case series reports on the use of guided bone regeneration (GBR) and coronal advancement flap with resorbable membrane and allograft. **Materials and methods:** Records of 14 patients (7 male, 7 female) with a mean (SD) age of 36.78 (13.9) years who were treated for soft tissue recessions around implant-supported restorations in the maxillary central or lateral incisor location were analysed. Implant diameters ranged from 3.3-4.7 mm. All patients had bone loss confined to the labial surface of the implant. A solvent-dehydrated particulate mineralized allograft (Puros Cancellous Bone Allograft, Zimmer Biomet Dental, Palm Beach Gardens, FL) and a resorbable membrane (CopiOs Pericardium, Zimmer Biomet Dental) were used in a GBR surgical procedure in combination with a roughened titanium tenting screw placed 3-4 mm below the implant platform to restore unesthetic defects in the anterior maxilla. **Results:** All postoperative tissue changes from their preoperative states were statistically significant ($p < 0.05$, Wilcoxon Signed-Rank test). Mean [SD, 95% Confidence Interval (CI)] preoperative crestal bone thickness (measured 2 mm from crest and mid-implant buccal bone

thickness) increased by 1.84 (0.89, 1.32-2.35) mm and 2.07 (0.81, 1.60-2.53) mm, respectively, approximately one year after treatment ($p < 0.001$). Significant mean (SD, 95% CI) increases of 1.28 (0.53, 0.97-1.58) mm, 1.29 (0.81, 0.82-1.75) mm and 1.23 (0.53, 0.92-1.53) mm were also noted in soft tissue thickness, keratinized tissue width, and gingival height, respectively ($p < 0.001$). **Conclusion:**Use of the allograft and xenogenic membrane effectively increased alveolar hard and soft tissue dimensions in the esthetic zone of the anterior maxilla. Future prospective clinical trials with a control group are needed to compare this technique with conventional methods such as connective tissue graft.

Short title: Management of implant labial mucosal recession

Key Words: esthetic, gingival recession, maxillary implants, pericardium membrane, allograft, augmentation

INTRODUCTON

The high predictability of implant-supported restorations has led to a shift in focus from implant survival to achieving natural-appearing outcomes, particularly in the esthetic zone of the anterior maxilla. Esthetic outcomes are directly affected by the soft tissue biotype, trajectory of available bone, and resorptive characteristics of the labial plate, all of which can dictate the location of the lip, architecture of the free gingival margin, and position of the implant relative to the residual alveolar ridge.[1]

Gingival height is influenced by the position of the underlying bone and the patient's soft tissue biotype. Peri-implant bone loss can result in soft tissue resorption followed by plaque attachment at or near the implant-abutment interface. This, in turn, can trigger soft tissue inflammation with additional bone loss and gingival recession.[2-6] It has been reported that gingival margin levels may be affected by the thickness of the gingival tissues, and that a thin tissue biotype may favor apical displacement of the soft tissue margin.[7] Maintaining an adequate width (~2 mm) of keratinized gingiva around dental implants has been reported to be essential for optimal gingival health.[2. 5, 7] However , this has been disputed.[2-3, 8-9] One study[6] reported a correlation between the presence of keratinized tissue, plaque levels and the incidence of mucositis, and theorized that sites with minimal keratinized tissue might be prone to a lower incidence of periodontal pocket formation.[3, 10]

In the anterior maxilla, however, the contribution of thick, keratinized gingiva to implant esthetics has not been disputed. As a general rule, some clinicians anticipated that 1 mm of gingival recession could be expected from the time of abutment connection

surgery.[11] As labial bone thickness resorbs, there is a corresponding loss in labial soft tissue thickness around the implant.[12-13] Moderate recession can make thin, pink gingival tissues appear dark due to the presence of the underlying metal abutment and implant, and further bone loss can cause unsightly metal exposure above the gingival margin. In general, implants carry a higher risk of soft tissue complications when placed in thin tissue biotypes or with labial inclinations when the labial plate thickness is <2 mm.[12-14] Use of an opaque abutment, such as zirconia, has been reported to produce the least amount of gingival color change when gingival thickness was <2 mm, whereas any abutment material resulted in satisfactory esthetics when gingival tissue thickness was >2 mm.[13, 15]

In order to identify predictors of gingival recession around single-tooth restorations in the anterior maxilla, it has been reported that only a buccal shoulder position of the implant (OR = 17.2) was associated with midfacial gingival resorption.[16] For interproximal tissues, ridge recontouring was associated with recession of both mesial (OR = 3.4) and distal (OR = 11.2) papillae.[16] In addition, mesial and distal papilla recession was associated with bone loss around a periodontally involved tooth that was mesial (OR = 2.1) or distal (OR = 2.7) to the implant itself, respectively.[16] In another study, Cosyn et al.[17] utilized the Pink Esthetic Score[18] (PES) to evaluate the esthetic results of implants immediately placed and provisionally restored with single-tooth restorations after tooth extraction. All patients had intact sockets with a thick gingival biotype; however, gingival recession in 24% of the cases resulted in esthetic failure at 1 year.[17]

To address bone loss and associated gingival recession around implants in the esthetic zone, guided bone regeneration[19] (GBR) and soft tissue augmentation[20-21] are often performed. When multiple implants are placed in the esthetic zone, vertical and horizontal bone augmentation of more than 2 mm from the implant platform is necessary to overcome the normal pattern of bone remodeling and soft tissue recession.[22] The use of coronally advanced flaps and connective tissue grafts for treating gingival recessions can sometimes jeopardize the esthetic appearance of the treatment sites in both color and tissue thickness as compared to the adjacent soft tissues.[23] Thoma et al.[24] conducted a systematic literature review and reported that the combination of an apically positioned flap/vestibuloplasty and soft tissue augmentation using a free gingival graft, subepithelial connective tissue graft or collagen matrix resulted in a 1.4-3.3 mm increase of keratinized tissue. Overall, connective tissue augmentation resulted in the best volume of soft tissue gains at implant and partially edentulous sites, and a combination of better papilla fill and higher marginal mucosal levels as compared to non-grafted sites around immediately placed dental implants.[24]

This retrospective clinical case series reports on the findings of an innovative surgical technique designed to restore hard tissue profiles and increase keratinized gingiva around dental implants in the esthetic zone.

Materials and methods

Institutional Review Board Services approval was granted for the present retrospective study. Treatment records were reviewed to identify all patients who had been referred to

the lead author's private surgery practice for treatment of facial bone loss and gingival recession around at least 1 implant-supported, single-tooth restoration in the maxillary esthetic zone (**Fig. 1a-h**). To control for concomitant factors that could potentially influence outcomes, the charts were then sorted to only include periodontally and systemically healthy nonsmokers who were at least 18 years of age with a soft tissue dehiscence at the buccal aspect more than 2 years after loading. Implants had to be free of periimplantitis and there could be no interproximal attachment loss for the teeth neighboring the implant. For reference purposes, patients were required to have an unrestored and normally positioned contralateral tooth without a recession defect. Patients also had to have completed a 1-year postoperative clinical evaluation. Data from the patient records was entered into a digital spreadsheet located in a secure, password-protected database.

Because achieving an ideal esthetic result in a compromised site is challenging and sometimes impossible,[25] all initial evaluations included a discussion to understand the patient's desires and expectations. The potential for unexpected complications that could compromise the final results and a review of treatment alternatives were also discussed.

Assessment of soft tissue thickness, keratinized tissue width, gingival margin height, crown length and facial bone thickness

Patients were next examined intraorally to assess oral hygiene, soft tissue health, the position and emergence profile of the implant relative to the labial plate and adjacent teeth, gingival contour, percentage of gingiva visibility when the patient smiled, and the shapes of the prosthetic and clinical crowns.

A standardized (XCP, Rinn Dentsply, York, PA) periapical radiograph and cone beam computed tomography (CBCT) scan were taken to assess the pre- and postoperative dimensions of the peri-implant crestal bone defect, and labial plate thickness at the midsection of the implant and at the crest of the ridge.[26] A digital caliper, CBCT scan with the lip retracted, and a periodontal probe were used to measure soft tissue thickness (1.5 mm below gingival margin), keratinized tissue width, and gingival margin height, respectively. An unrestored contralateral tooth normally positioned without recession defect used as a reference.[27] Keratinized tissue height was measured from the soft tissue margin and the mucogingival junction. Implant buccolingual angulation was recorded[12] as cingulum, incisal, or labial based on the screw access hole position on provisional restorations. Peri- and postoperative implant labial bone thickness at the crestal (2 mm from crest) and mid-implant levels were measured on sectional CBCT scans.

Augmentation procedure

Only patients with bone loss confined to the labial surface of the implant were selected and treated with a GBR protocol to resolve their bone defects. Decontamination of the implant surfaces was not performed because no study subjects exhibited signs of periimplantitis-related infection or purulence around the peri-implant sulcus. Patients with implants placed at severe labial inclinations or too deep relative to the crestal bone were excluded from GBR treatment and the present analysis.

On the day of surgery, the patient was asked to rinse with 0.12% chlorhexidine gluconate (15 mL) prior to IV sedation. A crestal incision and distal, curvilinear, vertical incision that followed the gingival margin of the distal proximal tooth were made. A full-thickness, subperiosteal "open book"[28] flap was elevated to the labial aspect of the implant. A wide subperiosteal reflection was made to expose 2 to 3 times the treatment area, and the papilla was reflected on the mesial side of the implant site (**Fig. 1b**). Tissue was carefully removed from the osseous defect using a curette, and the site was irrigated to remove debris. The peri-implant soft tissue was released and advanced by scoring the periosteum so that tension-free closure could be achieved around the neck of the implant. This is done because moderate graft resorption could occur if there were an inadequate tissue seal around the implant neck or if tension-free closure was not achieved. To reduce intraoperative bleeding at the graft site, the periosteal release was the last step before graft placement.

Particulate mineralized bone allograft material (Puros Cancellous Bone Allograft, Zimmer Biomet Dental, Palm Beach Gardens, FL) was packed into the defect and over-

contoured by approximately 20-30% to compensate for the anticipated apical migration and partial resorption of the material due to remodeling (**Fig. 1d**). This allograft was selected for use because of its documented predictability in regenerating new bone without leaving a significant quantity of residual particles after healing.[29-33] Prior to use, the allograft material was hydrated according to the manufacturer's directions and mixed with the patient's blood, which served as a coagulant. After graft placement, the material was covered with a resorbable membrane (CopiOs Pericardium, Zimmer Biomet Dental) and a wide healing abutment was connected to the implant. A roughened titanium tenting screw was placed 3-4 mm below the implant platform to create a tenting effect over the graft site and help to hold the particulate material in place (**Fig. 1c**). The resorbable membrane was selected because of research showing that its use with the selected cancellous allograft resulted in a greater volume of new bone formation in extraction sockets than either use of the cancellous allograft without a membrane or use of no augmentation materials at all.[34,35]

The mucoperiosteal flap was approximated and sutured in place (**Fig. 1e**). Intraoral photographs were taken before and after surgery as a visual record. The patient was provided with postoperative instructions, antibiotics, and analgesics, and dismissed until a follow-up visit 7-10 days later. After three months of healing, the patient was reappointed and previous clinical measurements were repeated. All patients wore an interim prosthesis during the healing period of 4 months. After 4 months, all implants were restored for 4-5 months with a screw-retained provisional prosthesis (**Fig. 1f**), and then definitively restored with either a screw-retained or cement-retained single-tooth restoration (**Fig. 1g**), depending on patient need.

RESULTS

Records of 14 patients (7 male, 7 female) with a mean (SD) age of 36.78 (13.9) (range = 20-64) years met the inclusion criteria for this retrospective clinical case series. The primary patient complaint was an unfavorable esthetic appearance when smiling because of implant surface exposure and/or disharmony in the scalloping of the marginal soft tissues. All patients successfully completed periodontal surgery and were not taking medications known to interfere with periodontal and peri-implant tissue health or healing. Implants were placed in either the maxillary central (n = 6) or lateral (n = 8) incisor locations. Implant diameters ranged from 3.3 to 4.7 mm. One patient presented with 3 implants with mid-facial recession. One implant was removed in this patient so that only 2 implants were treated. All other patients presented with a single implant each. Distributions of patients and implants as well as preoperative soft and hard tissue measurements are summarized in Table 1 and 2.

Postoperative results are summarized for each patient in Table 3 and cumulative findings are presented in Table 4. There were no complications or adverse events during surgery or postoperative healing. All postoperative tissue changes from their preoperative state were statistically significant ($p < 0.05$, Wilcoxon Signed-Rank test). The mean [SD, 95 % Confidence Interval (CI)] of pre-operative crestal (2 mm from crest) and mid-implant buccal bone thickness increased by 1.84 (0.89, 1.32-2.35) mm and 2.07 (0.81, 1.60-2.53) mm, respectively, approximately one year after treatment ($p <0.001$).

Significant increases were also noted in mean (SD, 95% CI) soft tissue thickness [1.28 (0.53, 0.97-1.58) mm], keratinized tissue width [1.29 (0.81, 0.82-1.75) mm], and gingival height [1.23 (0.53, 0.92-1.53) mm] ($p < 0.001$).

DISCUSSION

The goal of the GBR procedures in the present cases was to correct gingival recessions by restoring hard tissue profiles around dental implants in the esthetic zone. The efficacy of bone allografts and GBR surgical protocols in repairing alveolar defects and rebuilding resorbed ridges is documented in the dental literature.[36-38] While some allogenic tissues have demonstrated efficacy in soft tissue augmentation,[39,40] the use of pericardium membranes for soft tissue augmentation is not well documented in dentistry. In the present retrospective clinical case series, use of the pericardium membrane in combination with a particulate mineralized allograft resulted in approximately 1.0 mm of mean gain in soft tissue thickness, keratinized tissue width, and gingival height. The successful use of GBR in this group of patients could be attributable, in part, to the exclusion of patients with signs of infection and the extensive experience of the authors in treating periodontal defects through GBR. For some less-experienced clinicians, there may also be a learning curve before optimum results can be achieved.

Kokich et al.[41] reported that patients considered more than a 2 mm discrepancy in gingival margin height to be unesthetic, similar to those of general dentists. Conversely, dentists showed very low tolerance for any discrepancy in papilla height, but most laypersons were not able to identify severely compromised papilla height.[41] In another

study,[25] two adjacent maxillary implants were evaluated after autogenous block grafting in 10 consecutive patients. Similar to the findings of Kokich et al.,[41] authors[25] reported that, although the interdental papilla was severely deficient in 40% of the cases, patients still reported that their results were “acceptable” or better.

In the absence of histologic evidence in this retrospective study to explain the observed increases keratinized tissue height and gingival thickness, several theories may be considered. First, although no prior reports of a GBR procedure resulting in clinical increases of both keratinized tissue height and gingival thickness were found in the dental literature by the present authors, a limited number of retrospective studies[13,42] have reported an increase in soft tissue thickness around dental implants primarily in the anterior maxilla after increasing the thickness of the facial bone through GBR. Further research is needed to understand these observed correlations between bone and soft tissue thickness. Second, the pericardium membrane placed over the particulate graft in the present study was essentially a collagen matrix similar to a connective tissue graft, which adds to the thickness of their overlying tissue.[43] For example, Vanhoutte et al.[44] reported that use of a connective tissue graft in conjunction with a socket preservation procedure could almost completely counteract changes in the external soft tissue profile after bone remodeling. Third, scoring of the periosteum and underlying bone tissue prior to grafting and foreign body reaction from placement of a graft and membrane may result in scar tissue formation that augments the soft tissue profile. While the goal of the GBR procedure was to treat bone defects in the present clinical case series, improvements were coincidentally observed no only in the soft tissue dehiscence, but also in the keratinized tissue width and soft tissue thickness.

In the present analysis, the soft tissue profile of a contralateral tooth was used as a reference for evaluating the soft tissue profile of the implant-supported, single tooth restoration. Despite the significant interfacial differences that have been well documented in the dental literature regarding soft tissue attachment to dental implants as compared to natural teeth, such comparisons between single tooth restorations and neighboring natural teeth has been widely used internationally since its introduction nearly a decade ago by Führhauser et al.,[45] who made it an integral component of the Pink Esthetic Score (PES) used to evaluate the esthetic outcomes of dental implants. Specifically the PES compares seven different soft tissue variables between a natural reference tooth and a dental implant restoration: mesial papilla, distal papilla, soft-tissue level, alveolar process deficiency, soft-tissue color and soft-tissue texture.[45] While the full PES scoring system was not used in the present analysis, use of the reference tooth to compare soft tissue parameters was nonetheless an essential.

Patients in the present clinical case series expressed satisfaction with the augmentation procedures and the final appearance of their smiles, which has been judged to be important by clinicians and laypersons alike.[46] For anterior maxillary restorations, it is important to evaluate the smile line on full animation to measure gingival show.[47] An esthetic smile has been described as approximately 2-4 mm of maxillary incisor show at rest, and 1-2 mm display of gingival show with full animation.[47] The gingival level of maxillary canines and incisors should coincide while the lateral incisor gingival level is more coronal by 0.5–2 mm.

As implant therapy is prosthetically driven, it is crucial for the clinician to be able to visualize and have the final prosthetic outcome in mind prior to any augmentation

procedures for implant site development. The position of the implant should be such that the final outcome of the restoration includes all the characteristics of a naturally appearing and fully functional dental restoration. This includes appropriate emergence profile, correctly matched crown shape and form, as well as healthy and appropriately contoured gingival tissue.

Several factors appear to influence the level of soft tissue around dental implants such as type of mucosa (keratinized vs. non-keratinized), mucosal thickness, facial/buccal bone crest level and thickness, interproximal bone crest level, depth of implant platform, micro and macrostructure of the implant neck, implant-abutment and prosthesis connection and surgical technique. [1,13,16, 27] The present technique is not ideal for restoring the gingival margins for poorly positioned implants or when there is significant thread exposure. For example, implants placed outside of the alveolar housing or with significant labial inclination associated with labia bone loss should be excluded. Le et al.[48] treated patients with vertical ridge augmentation using mineralized allograft placed around titanium screws to tent out the soft tissue matrix and periosteum. Briefly, titanium screws 1.5 mm in diameter were placed in the deficient alveolar ridges so that 5 to 7 mm of screw threads were exposed.[48] Mineralized allograft particles were mixed with the patient's blood and placed to completely cover the screws, and a resorbable collagen membrane was placed over the graft site.[48] After 4 to 5 months of healing, the sites were covered and the screws were removed and implants were placed.[48] Of 15 patients prospectively treated, the vertical augmentation was 9.7 mm, although 5 patients had to first undergo second-stage grafting procedures to achieve ideal ridge heights.[48] This screw "tent-pole" technique was used in 6 patients to treat facial bone loss.[48]

Zucchelli et al.[27] reported on a novel surgical-prosthetic treatment for implants with buccal soft tissue dehiscence defects in the esthetic zone. Using an unrestored contralateral tooth as a reference, the technique involved removing the crown, shortening the abutment, and then treating the dehiscence defect with a coronally advanced flap and connective tissue graft.[27] After 1 year, mean soft tissue dehiscence coverage was 96.3% with complete coverage in 75% of the treatment sites.[27] While esthetics were enhanced and patients were doubtlessly satisfied during short-term follow-up, the ability to camouflage a bony defect with or without exposed implant threads is highly limited without the support of the underlying bone, which is the main cause of soft tissue recession.[13,49,50] In addition to soft tissue recession, marginal bone loss has been associated with increased peri-implant stress concentrations in the crestal bone region. Over time, elevated stress concentrations can trigger additional bone loss and further soft tissue recession.[51] If left untreated, increased stresses can result in screw-loosening, metal fatigue and component fracture over time.[51,52] Implants placed in the anterior maxillary jaw with thin buccal plates are highly susceptible to the adverse effects of marginal bone loss.[51,52]

In contrast, the present case series found that the benefits of guided bone regeneration in the treatment of gingival recession were threefold. First, restoring the missing buccal bone decreased the risk of developing peri-implantitis from bacterial biofilm attachment to the exposed implant-abutment crevice and roughened implant surface. Second, the present technique increased soft tissue thickness, which made the restored tissues more resistant to future recession and mask the underlying titanium components.[40, 52,53] Third, guided bone regeneration also unexpectedly increased the

width of keratinize tissue, which has also been reported to help provide a peri-implant soft tissue seal against bacterial invasion, in addition to providing resistant against recession.[48] While increases in soft tissue thickness and keratinized tissue width have been reported after placement of connective tissue and free gingival grafts,[48] this phenomena has not been previously reported after GBR procedures around dental implants. The use of solvent-dehydrated, mineralized bone allograft and xenogenic pericardium membrane effectively increased alveolar hard and soft tissue dimensions in the esthetic zone of the anterior maxilla. This new concept of bone-driven soft tissue transformation may serve as an alternative for soft tissue augmentation in instances where tissue thickening is needed. However, the retrospective nature of the study and the lack of a control group or information of the long-term outcome of the procedure, as well as the multiple used methods that makes highlighting the contribution of each of the methods difficult - i.e. the tenting screw or pericardium membrane, are limitations of the study. Ideally, a prospective clinical trial with a control group is needed to assess whether this technique is in fact an improvement in handling gingival recession for implants placed in the esthetic zone as compared to standard surgical methods.

CONCLUSION

Gingival recession, keratinized tissue width and soft tissue thickness can be positively influenced by hard tissue augmentation with appropriate grafting materials.

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TABLES

Table 1- Characteristics of implant sites with gingival recession.

Patient No.	Sex	Implant Diameter (mm)	Angulation*	Maxillary Location
1	M	4.7	Incisal	Left Central
2	M	3.75	Incisal	Right Lateral
3	M	3.75	Incisal	Left Central
4	F	3.3	Cingulum	Right Central
5	M	3.8	Cingulum	Right Central
6	M	3.7	Cingulum	Right Lateral
7	F	3.3	Incisal	Left Lateral
8	F	4.5	Incisal	Right Lateral
9	F	3.8	Cingulum	Left Central
10	M	4.0	Labial	Left Lateral
11	M	3.7	Cingulum	Left Central
12	F	3.7	Incisal	Right Lateral
13	F	3.3	Cingulum	Right Lateral
14	F	3.3	Cingulum	Right Lateral

* Implant buccolingual angulation was recorded[12] as cingulum, incisal, or labial based on the screw access hole position on provisional restorations

Table 2. Preoperative soft and hard tissue measurements (mm)

Patient No.	**Labial Bone Thickness**		**Soft Tissue Thickness**	**Keratinized Tissue Width**		**Gingival Margin Height**
	Midsection of Implant	Crest of Ridge		Implant	Adjacent Tooth*	
1	0	0	1.2	1.3	2.6	1.2
2	0	0	1.1	1.51	3.14	1.1
3	0	0	1.3	1.68	3.56	1.2
4	1.1	0	1.6	2.8	3.98	1.9
5	0	0	2.6	2.95	3.08	2.6
6	1.15	1.2	1.4	2.28	3.44	1.4
7	1.3	0	1.4	2.02	3.01	2.1
8	1.25	1.3	1.4	5.28	6.44	1.1
9	1.5	0	1.5	1.77	4.49	1.5
10	0	0	1.3	2.97	4.89	2.4
11	0	0	1.3	1.2	3.60	1.3
12	1.1	0	2.4	3.76	4.33	1.7
13	1.6	0	1.6	4.54	4.98	2.2
14	0	0	1.4	1.4	2.78	1.3

*For comparative purposes only

Table 3. Postoperative soft and hard tissue measurements (mm)

Patient	**Labial Bone Thickness**		**Soft Tissue Thickness**	**Keratinized Tissue Width**		**Gingival Margin Height**
No.	Midsection of Implant	Crest of Ridge		Implant	Adjacent Tooth*	
1	2.8	1.2	2.3	2.1	2.6	2.3
2	3.2	2.6	2.8	3.78	3.14	2.9
3	2.7	3.3	3.4	2.77	3.56	3.2
4	2.8	0	2.6	4.01	3.98	3.0
5	2.9	2.1	3.38	3.25	3.08	3.1
6	3.1	2.5	2.8	3.11	3.44	2.5
7	2.8	2.4	3.1	3.81	3.01	2.9
8	2.0	2.5	2.8	6.23	6.44	2.8
9	2.6	2.8	3.6	2.76	4.49	3.1
10	2.3	1.2	1.9	4.7	4.89	2.5
11	3.1	2.1	2.7	3.6	3.60	2.9
12	2.4	1.6	2.7	4.1	4.33	3.2
13	2.9	2.8	2.9	5.0	4.98	3.1
14	2.4	1.2	2.4	4.3	2.78	2.7

*For comparative purposes only

Table 4. Cumulative post-operative hard and soft tissue changes (mm), including the 95% Confidence Interval (CI) of the changes.

Clinical Measurements	N	Mean (SD) of Changes	95% CI of mean changes	Median	P Value*
Labial Bone Thickness: Midsection of Implant	14	2.07 (0.81)	1.60-2.53	2.125	0.0001
Labial Bone Thickness: Crest of Ridge	14	1.84 (0.89)	1.32-2.35	1.85	0.0002
Soft Tissue Thickness	14	1.28 (0.53)	0.97-1.58	1.35	0.0001
Keratinized Tissue Width	14	1.29 (0.81)	0.82-1.75	1.04	0.0001
Gingival Margin Height	14	1.23 (0.53)	0.92-1.53	1.25	0.0001

*Wilcoxon Signed-Rank Test

LEGENDS FOR ILLUSTRATIONS

Figure 1 (a-h). Preoperative clinical view shows a maxillary left central incisor with gingival recession and discoloration cause by exposure of the underlying dental implant (a); surgical exposure showing dehisced labial bone and exposed implant surface (b); tenting screw placement (c); allograft material mixed with the patient's blood placed on the labial surface of the implant and covered then with a resorbable membrane (CopiOs Pericardium) (d); a wide healing abutment was connected to the implant to create an additional tenting effect over the graft site and help to contour the overlying soft tissue (e); screw-retained provisional restoration delivered after 4 months of healing (f); follow-up clinical view shows significant improvement in soft tissue parameters with a corresponding decrease in crown length at 1 year (g); postoperative CT scan taken 2 years after GBR procedure shows restoration of hard and soft tissue dimensions (h).