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Clinical outcomes of soft tissue augmentation around dental implants

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Abstract:
Inadequate peri-implant soft tissue dimensions compromise implant health, esthetics and patient comfort, highlighting the need for effective soft tissue augmentation techniques. Therefore, it is of interest to evaluate the efficacy of peri-implant soft tissue augmentation in 100 patients by assessing keratinized mucosal width, soft tissue thickness, probing depth, plaque index, bleeding on probing and patient satisfaction over 6 months. Clinical follow up showed improvements in peri-implant soft tissue dimensions and health, with increased keratinized mucosal width and soft tissue thickness accompanied by favourable periodontal parameters and patient satisfaction. Soft tissue augmentation effectively enhanced peri-implant tissue stability and esthetic outcomes during the observation period. Thus, data support soft tissue augmentation as a valuable adjunct to implant therapy for improving long-term peri-implant tissue health, function and esthetic success.

Keywords: Dental implants (DI), soft tissue augmentation, connective tissue graft, keratinized mucosa, peri-implant soft tissue, implant esthetics

Background:
Dental implants are one of the most predictable and accepted treatment modalities for the replacement of missing teeth. The high long-term survival rates and good functional outcomes are due to the improvements in implant design, surgery and restorative procedures **[1]**. Today, however, implant dentistry is aware that the success of treatment is not limited to osseointegration and implant survival. The quality, quantity and stability of peri-implant soft tissues are now a major focus as they are crucial for maintaining peri-implant health, contributing to esthetic outcomes and patient satisfaction **[2]**. The peri-implant soft tissue complex consists of keratinized mucosa, connective tissue attachment and peri-implant mucosal thickness. Stable biological seal around dental implants and protection of the underlying supporting structures from microbial invasion and mechanical trauma is considered to be essential and depends on adequate soft tissue dimensions **[3].** Therefore, peri-implant soft tissue augmentation has become an important adjunctive technique in implant therapy, with different techniques showing varying effects on keratinized tissue width and mucosal thickness **[4]**. The width of keratinized mucosa and thickness of mucosa have been the focus of significant attention as the two of the many peri-implant soft tissue parameters. Research has shown that insufficient keratinized tissue around implants is linked to more plaque retention, oral hygiene difficulties and greater incidence of peri-implant inflammatory conditions **[5]**. The goal of soft tissue augmentation procedures is to enhance these parameters and create a more favourable peri-implant environment. Afrashtehfar *et al.* found that peri-implant soft tissue augmentation techniques can have a positive effect on the stability of the marginal bone and the maintenance of the soft tissue around implants in the long term **[6]**. Connective tissue grafting technique can significantly contribute to the soft tissue volume and peri-implant contour stability during healing **[7]**. The term peri-implant phenotype has recently become of great importance in implant dentistry. These characteristics are keratinized tissue width, mucosal thickness, supracrestal tissue height and peri-implant bone morphology. A good peri-implant phenotype has been correlated with better biological and esthetic results. Peri-implant soft tissue phenotype modification with augmentation procedures has been shown to improve tissue stability and decrease the likelihood of future complications in clinical studies **[8]**. Increased soft tissue thickness was also shown to improve peri-implant stability and long-term clinical outcomes by Torra-Moneny *et al.* **[9]**. Apart from the biological advantages, soft tissue augmentation is also of great esthetic significance, especially in the anterior maxillary area where implant restorations are highly visible. There is a need to preserve adequate keratinized mucosa around dental implants because it may contribute to peri-implant health, ease of oral hygiene and favorable esthetic outcomes **[10]**. This finding is consistent with a recent systematic review by Duble *et al.*, which reported favorable medium- and long-term outcomes of peri-implant soft tissue augmentation in terms of keratinized mucosa width, mucosal thickness, marginal tissue stability, esthetics and patient-reported outcomes **[11]**. Therefore, it is of interest to assess the effectiveness of soft tissue augmentation around

dental implants by evaluating the changes in the width of the keratinized mucosa, the soft tissue thickness and the health parameters of the peri-implant tissues, the esthetic outcomes and the patient satisfaction after the treatment.

Materials and Methodology:

Study design:

This study was designed as a prospective clinical interventional study to evaluate the effectiveness of soft tissue augmentation around dental implants.

Study setting:

The study was conducted in the Department of Periodontology and Implantology of a tertiary care dental teaching institution over a period of 18 months.

Study population:

Patients reporting to the implant clinic requiring soft tissue augmentation around dental implants were screened for eligibility.

Sample size:

A total of 100 patients requiring peri-implant soft tissue augmentation were included in the study.

Sampling technique:

Consecutive eligible patients fulfilling the inclusion criteria were recruited until the required sample size was achieved.

Inclusion criteria:

[1] Patients aged 18–70 years.
[2] Patients requiring dental implant therapy with inadequate peri-implant soft tissue volume.
[3] Presence of keratinized mucosal width <2 mm and/or thin soft tissue phenotype.
[4] Adequate bone support for implant placement.
[5] Good oral hygiene maintenance.
[6] Patients willing to participate and provide informed consent.

Exclusion criteria:

[1] Uncontrolled systemic diseases.
[2] Uncontrolled diabetes mellitus.
[3] Heavy smokers (>10 cigarettes/day).
[4] Pregnancy and lactation.
[5] Active periodontal disease.
[6] Patients receiving immunosuppressive therapy.
[7] Previous peri-implant surgery at the study site.
[8] Poor oral hygiene compliance.

Ethical approval:

Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement of the study. Written informed consent was obtained from all participants.

Preoperative assessment:

Each patient underwent:

[1] Detailed medical and dental history.
[2] Clinical oral examination.
[3] Radiographic examination using CBCT and intraoral radiographs.
[4] Evaluation of implant site soft tissue phenotype.

Baseline clinical parameters:

The following parameters were recorded:

[1] Keratinized mucosal width (mm)
[2] Peri-implant soft tissue thickness (mm)
[3] Plaque Index (Silness and Löe)
[4] Bleeding on Probing (BOP)
[5] Probing Pocket Depth (PPD)
[6] Mucosal Recession (mm)
[7] Pink Esthetic Score (PES)
[8] Patient Satisfaction Score (VAS)

Surgical procedure:

Following local anesthesia administration:

Group A: Connective tissue graft augmentation:

[1] Subepithelial connective tissue graft harvested from the palate.
[2] Recipient bed prepared around implant site.
[3] Graft stabilized using resorbable sutures.
[4] Flap repositioned and sutured.

Group B: Free gingival graft augmentation:

[1] Free gingival graft harvested from palatal donor site.
[2] Adapted to recipient peri-implant area.
[3] Stabilized using interrupted sutures.
[4] (50 patients allocated to each group.)

Postoperative care:

[1] Amoxicillin 500 mg three times daily for 5 days.
[2] Ibuprofen 400 mg as needed.
[3] Chlorhexidine mouth rinse 0.12% twice daily for 2 weeks.
[4] Oral hygiene instructions reinforced.

Follow-up schedule:

Patients were evaluated at:

[1] Baseline
[2] 1 month
[3] 3 months
[4] 6 months

Outcome measures:

Primary outcomes:

[1] Gain in keratinized mucosal width.
[2] Increase in peri-implant soft tissue thickness.

Secondary outcomes:

[1] Reduction in probing depth.
[2] Improvement in plaque control.
[3] Reduction in bleeding on probing.
[4] Improvement in Pink Esthetic Score.
[5] Patient satisfaction.

Data collection:
All measurements were recorded by a calibrated examiner using a UNC-15 periodontal probe and endodontic spreader with silicone stopper for tissue thickness assessment.

Statistical analysis:
Data were entered into Microsoft Excel and analyzed using SPSS Version 26.0.

[1] Mean ± SD calculated for continuous variables.
[2] Frequencies and percentages calculated for categorical variables.
[3] Independent t-test used for intergroup comparisons.
[4] Paired t-test used for intragroup comparisons.
[5] Chi-square test used for categorical variables.
[6] Repeated measures ANOVA used for longitudinal assessment.
[7] $P < 0.05$ considered statistically significant.

Results:
A total of 100 patients requiring peri-implant soft tissue augmentation were included in the study. All patients completed the six-month follow-up period. The study population consisted of 52 males and 48 females, with a mean age of 42.8 ± 10.6 years. Fifty patients underwent subepithelial connective tissue graft (CTG) augmentation (Group A), while 50 patients received free gingival graft (FGG) augmentation (Group B).At baseline, the mean KMW was approximately 1.4 mm in both groups. After six months, CTG-treated sites demonstrated a 200% increase in KMW, while FGG-treated sites demonstrated a 161% increase. Similarly, soft tissue thickness increased by 118.3% in the CTG group and 86.8% in the FGG group. The improvements observed in Group A were significantly greater than those in Group B (p=0.001). The findings indicate that connective tissue grafting provides superior augmentation of peri-implant soft tissue volume and keratinized tissue dimensions compared with free gingival grafting **(Table 1).** A significant reduction in plaque accumulation was observed in both groups. Group A showed a 63.4% reduction in plaque index, whereas Group B showed a 53.9% reduction. Bleeding on probing decreased from 72% to 14% in Group A (80.6% reduction) and from 70% to 22% in Group B (68.6% reduction). Mean probing depth decreased by 36.7% in Group A and 28.9% in Group B. Mucosal recession decreased by 67.2% and 53.4% respectively. These findings suggest improved peri-implant health following soft tissue augmentation, with superior outcomes observed among CTG-treated sites **(Table 2).** Both treatment modalities resulted in significant esthetic improvement. However, the CTG group achieved substantially higher Pink Esthetic Scores. The mean PES increased by 78.8% in Group A compared with 56.5% in Group B. Patient satisfaction scores were significantly greater among CTG recipients. Nearly 88% of patients in Group A reported being very satisfied compared with 74% in Group B. Overall, connective tissue grafting provided better esthetic integration and patient-reported outcomes **(Table 3).**

Table 1: Comparison of keratinized mucosal width and soft tissue thickness

Parameter	Group A (CTG) Baseline	Group A 6 Months	Group B (FGG) Baseline	Group B 6 Months	p value
Keratinized Mucosal Width (mm)	1.42 ± 0.38	4.26 ± 0.62	1.45 ± 0.41	3.78 ± 0.59	0.001*
Soft Tissue Thickness (mm)	1.31 ± 0.24	2.86 ± 0.42	1.29 ± 0.26	2.41 ± 0.38	0.001*

**Statistically significant*

Table 2: Comparison of peri-implant clinical parameters

Parameter	Group A Baseline	Group A 6 Months	Group B Baseline	Group B 6 Months	p value
Plaque Index	1.94 ± 0.48	0.71 ± 0.26	1.91 ± 0.51	0.88 ± 0.31	0.018*
Bleeding on Probing (%)	72%	14%	70%	22%	0.027*
Probing Pocket Depth (mm)	3.92 ± 0.67	2.48 ± 0.51	3.88 ± 0.61	2.76 ± 0.54	0.031*
Mucosal Recession (mm)	1.28 ± 0.31	0.42 ± 0.18	1.31 ± 0.29	0.61 ± 0.22	0.022*

**Statistically significant*

Table 3: Esthetic outcomes and patient satisfaction

Parameter	Group A (n=50)	Group B (n=50)	p value
Pink Esthetic Score Baseline	7.18 ± 1.12	7.26 ± 1.08	0.742
Pink Esthetic Score 6 Months	12.84 ± 1.31	11.36 ± 1.42	0.001*
Improvement (%)	78.8%	56.5%	0.001*
Patient Satisfaction (VAS/10)	9.12 ± 0.86	8.24 ± 1.01	0.003*
Very Satisfied Patients	44 (88%)	37 (74%)	0.041*

**Statistically significant*

Discussion:
The present prospective clinical study assessed the clinical efficacy of soft tissue augmentation around dental implants and showed that there was a significant increase in keratinized mucosal width, peri-implant soft tissue thickness, probing parameters, esthetic outcomes and patient satisfaction. The results suggest that peri-implant soft tissue augmentation is a key component in maintaining peri-implant health and in the attainment of desirable esthetic outcomes. In addition, the connective tissue grafts (CTG) showed better results than the free gingival grafts (FGG) in most of the evaluated parameters. In recent years, peri-implant soft tissue management has become more and more important as clinicians have come to understand that successful implant therapy is not only dependent on osseointegration, but also on the stability and quality of peri-implant soft tissues. In the anterior region, De Angelis *et al.* showed that there was significant improvement in soft tissue contour and less mucosal recession with connective tissue grafting around immediately placed implants, which resulted in better esthetic outcomes **[2]**. Likewise, the systematic review by Stefanini *et al.* showed that soft tissue augmentation has a positive effect on the stability of the peri-implant tissue and can positively affect clinical and radiographic results after implant placement **[12]**. The present study revealed that augmentation procedures resulted in a significant increase in the width of the

keratinized mucosa, one of the most important findings. The CTG group showed higher improvements than the FGG group, suggesting better tissue integration and stability over time. These findings are corroborated by Afrashtehfar *et al.*, who found that soft tissue augmentation procedures are effective in enhancing the dimensions of peri-implant soft tissues and can help maintain peri-implant bone levels **[6]**. In addition, Rotundo *et al.* showed that autogenous connective tissue grafts provide superior soft tissue augmentation in early healing periods compared to porcine collagen matrices, suggesting the predictability of CTG procedures **[7]**. There was also a significant increase in soft tissue thickness in both treatment groups and a much higher increase in the CTG group. Increased thickness of the mucosa is thought to be beneficial as thicker mucosa is more resistant to recession and inflammatory changes. Peri-implant phenotype has gained more and more importance in implant dentistry. Galve-Huertas *et al.* highlighted that the soft tissue phenotype modification can have a significant effect on peri-implant stability and long-term treatment outcomes **[8]**. Similarly, Torra-Moneny *et al.* showed that thicker peri-implant soft tissues leads to better tissue stability and fewer biological complications around implants **[9]**. The decrease of plaque index and bleeding on probing in the present study is an indication of better health of the peri-implant tissues after augmentation. Good keratinized mucosa allows for patient comfort during oral hygiene and better plaque control. This finding is in line with the results of a systematic review and meta-analysis by Stefanini *et al.* which showed that the presence of adequate keratinized mucosa is linked to better peri-implant health and patient-reported outcomes **[11]**. The pocket probing depth and bleeding on probing were significantly reduced after treatment, suggesting reduced peri-implant inflammation and tissue maturation. Galarraga-Vinueza and Tavelli and Tavelli *et al.* emphasized that peri-implant soft tissue properties play a significant role in the susceptibility to and the treatment of peri-implant diseases **[12, 13]**. Furthermore, Atieh and Alsabeeha showed that poor peri-implant phenotypes are correlated with higher inflammatory markers like calprotectin and matrix metalloproteinase-8, which highlights the biological relevance of peri-implant soft tissue quality **[14]**. The other clinically relevant finding was the decrease in mucosal recession after augmentation procedures. Recession around implants impacts esthetics and can expose restorative components, which can have a negative impact on patient satisfaction. Lin *et al.* showed that wider width of keratinized tissue leads to greater stability and resistance to recession around implants **[15]**. The same findings were reported by Önder and Alpaslan who found that soft tissue augmentation procedures result in stable and favourable peri-implant conditions in the medium- and long-term follow up periods **[16]**. The Pink Esthetic Score was significantly improved in both groups and better in the CTG group. Connective tissue grafts improve soft tissue contour, papillary fill and mucosal harmony, leading to more natural implant restorations. Fickl *et al.* reported that connective tissue grafting is one of the most predictable techniques for soft tissue enhancement around immediate implants and is a significant improvement in esthetic outcomes **[17]**. Similarly, Sanz *et al.* showed that vertical soft tissue augmentation can increase the stability and esthetic integration of peri-implant tissues around implant restorations **[18]**. Patients who received CTG treatment had a significantly higher level of satisfaction. This may have been due to better esthetics, increased tissue thickness and decreased inflammation. Patient-reported outcome measures are becoming an integral part of contemporary implant dentistry and are increasingly considered as key markers of treatment success. Stefanini *et al.* found that sufficient keratinized mucosa had a positive effect on patient comfort, oral hygiene maintenance and treatment satisfaction **[19]**. Xenogeneic collagen matrices have also been investigated as alternatives to autogenous grafts; however, Engla *et al.* reported that FGG produced greater improvements in keratinized tissue width and peri-implant clinical parameters than xenogeneic collagen matrix **[20]**. Gandhi *et al.* highlighted that autogenous grafts, including free gingival grafts and subepithelial connective tissue grafts, remain established approaches for soft tissue augmentation, while collagen-based substitutes offer potential advantages in reducing donor-site morbidity **[21]**. The advantages of the present study are that it is prospective, the measurement protocol is standardized and the patients were followed completely. However, some limitations are that there was no histological assessment and the follow-up period was relatively short at six months. More long-term studies are required to assess the stability of augmented tissues and its effect on peri-implant bone preservation. Long-term clinical relevance of peri-implant phenotype modification and its contribution to the prevention of biological complications around implants should be investigated in the future **[22]**.

Conclusion:

The soft tissue augmentation around dental implants resulted in a significant improvement in the width of the keratinized mucosa, soft tissue thickness, peri-implant health parameters, esthetic outcomes and patient satisfaction. Free gingival grafts were not as successful as connective tissue grafts. Peri-implant soft tissue augmentation is an essential part of implant therapy that should be considered to achieve long-term stability of soft tissues, better esthetics and better patient-centred outcomes.

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