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Influence of soft tissue thickness on esthetic outcomes around dental implants

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Abstract:
Peri-implant soft tissue phenotype is an important determinant of esthetic integration and tissue stability following implant-supported rehabilitation. This prospective comparative study evaluated 110 patients, including 55 with thin and 55 with thick peri-implant soft tissue phenotypes, using esthetic, clinical and patient-reported parameters. Patients with thick soft tissues showed significantly higher pink esthetic score, white esthetic score, papillary fill and keratinized mucosal width, lower mucosal recession and greater patient satisfaction ($p<0.05$). Thick peri-implant soft tissues were associated with improved esthetic outcomes and greater tissue stability, while bleeding on probing and prosthetic complications were less frequent but not significantly different. These findings advance knowledge by emphasizing peri-implant phenotype assessment and appropriate soft tissue management for predictable long-term esthetic implant therapy.

Keywords: Dental implants (DI), gingival phenotype, pink esthetic score (PES), peri-implant soft tissue, white esthetic score (WES), esthetic outcome, implant prosthodontics

Background:
Beyond survival rates, adequate thickness of the mucosa plays a critical role in the success of implants, promoting greater tissue stability, less mucosal recession, better mucosal fill with papillae and desirable esthetic outcomes **[1].** Moreover, implants embedded in thick peri-implant soft tissue consistently achieved better scores in terms of Pink Esthetic Score (PES), more stable mucosal space and less facial recession than those in thin tissue biotypes **[2]**. It was also found that soft tissue augmentation surgeries can help patients have more esthetic outcomes in their patients with thin peri-implant mucosa, which was another major reason why soft tissue augmentation using techniques such as Peri-implant Phenotype Modification may also have clinical benefits in the long term **[3].** The term peri-implant phenotype refers to the characteristics of the keratinized mucosal width, of the mucosal thickness, of the supracrestal tissue height and of the morphology of the buccal bone. The combined effect of these biological factors affects peri-implant health, esthetic integration and peri-implant tissue maintenance **[4]**. A thorough analysis of these factors preceding the positioning of the implant can enable the clinician to assess the patient's risk when considering esthetic factors and plan for enhanced soft tissue management during treatment planning for implants in aesthetic zones **[5].** In recent years, there has been a growing emphasis on soft tissue management in contemporary implant dentistry and a strong focus on optimizing the soft tissue management in implant dentistry, which is through minimally invasive surgical techniques, connective tissue grafts, protocols for provisional treatment and digital treatment planning **[5, 6]**. Advances in surgical and prosthetic approaches have improved clinicians' ability to preserve or augment peri-implant soft tissues, thereby optimizing emergence profile, papillary architecture and overall esthetic integration of implant restorations **[7].** Besides, a number of techniques have been developed that now benefit clinicians in maintaining or improving peri-implant soft tissues and that improve the esthetic integration of implant restorations, especially in the anterior maxilla, to correct peri-implant mucosal deficiencies, as evidenced by a systematic evaluation **[6].** A well-planned implant is also crucial for the proper soft tissue support around the implant. The esthetic maturity of the soft tissue profiles and final outcome of the restorations are determined by a combination of the following factors: timing of restorations, position of implants, emergence profile design and provisionalization procedures. The maintenance of peri-implant mucosal contours and predictable esthetic rehabilitation can be possible with appropriate management during the restorative phase **[8].** Long-term studies have shown that soft tissue grafting around esthetic implants leads to good long-term peri-implant health with stable volume of the soft tissues around the implant. In conclusion, these results show how critical proper peri-implant soft tissue thickness is for preventing peri-implant soft tissue recession and for long-term esthetic success **[9].** Therefore, it is of interest to evaluate the effect of peri-implant soft tissue thickness on esthetic parameters related to dental implants by comparing the clinical parameters of esthetic outcomes between thin and thick peri-implant soft tissue phenotypes.

Materials and Methodology:
Study design:
This was a prospective observational comparative study was undertaken to assess the influence of peri-implant soft tissue thickness on esthetic outcome around dental implants.

Study setting:
The research was conducted in Department of Prosthodontics and Implantology of Tertiary Care Dental Teaching institution.

Study duration:
The study took place for 18 months.

Sample size:
The sample consisted of 110 consecutive patients who needed the placement of a single implant-supported restoration in the esthetic zone.
[1] Group I: Thin-soft tissue phenotype (n=55 patients)
[2] Group II: Thick-soft tissue phenotype (n=55 patients)

Inclusion criteria:
[1] Patients aged 18–65 years.
[2] Patient required a single implant in esthetic areas (maxillary or mandibular).
[3] Adequate bone volume for the implant placement without the need for major bone augmentation.
[4] Plaque index <20% good oral hygiene.
[5] Patients who are available and give informed written consent.

Exclusion criteria:
[1] Systemic disorders that result in uncontrolled healing, such as diabetes and blood disorders.
[2] Strong smokers (more than 10 cigarettes/hig)
[3] Untreated periodontitis.
[4] Pregnancy or lactation.
[5] Patients who are being treated with radiotherapy or bisphosphonate medications.
[6] Active peri-implant infection.
[7] Non-compliance of maintenance visits.

Clinical procedure:
The implants were placed under the standard surgical procedures and in the hands of experienced implantologists. Once the healing period was over, the dentures supported by the implants were fabricated by standard procedures in prosthodontics. Peri-implant soft tissue thickness was determined on the mid-facial aspect under anaesthesia with an endodontic rubber stopper periodontal probe. Patients were grouped as:
[1] Thin phenotype: Soft tissue thickness <2mm
[2] Thick phenotype: Soft tissue thickness >2 mm

Outcome measures:
After the definitive prosthesis placement the following esthetic parameters were analysed:
[1] Pink Esthetic Score (PES).
[2] White Esthetic Score (WES)
[3] Mid-facial mucosal recession (mm)
[4] Interdental papilla fill
[5] Peri-implant probing depth (PPD) is measured.
[6] Bleeding on probing (BOP)
[7] The width of the lining (keratinized) mucosa.
[8] The patient satisfaction will be measured by the Visual Analogue Scale (VAS)
Two independent, blinded evaluators took standardized intraoral photographs for esthetic evaluation.

Statistical analysis:
The data was entered in a Microsoft excel file and analyzed by using SPSS version 26.0. Data from continuous variables were summarized in the form of mean ± SD and categorical variables in the form of frequencies and percentages. Independent Student's t-test and Chi-squares or fisher's exact test were used for comparing the two groups, depending on the nature of the variables. The intraclass correlation co-efficient (ICC) was used to assess inter-observer agreement for the PES or WES assessment. P values <0.05 were considered statistically significant.

Results:
A total of 110 patients with single implant-supported restorations in the esthetic area were included in the study. Based on peri-implant soft tissue thickness, patients were classified into a thin phenotype group (<2 mm; n = 55) and a thick phenotype group (≥2 mm; n = 55). The Pink Esthetic Score (PES), White Esthetic Score (WES), peri-implant clinical parameters and patient satisfaction were evaluated. As shown in **Table 1**, the two groups were comparable in terms of demographic and implant-related characteristics. The mean age was 38.6 ± 9.2 years in the thin phenotype group and 40.1 ± 8.7 years in the thick phenotype group (p = 0.376). There were no statistically significant differences in gender distribution, implant location, or timing of implant placement between the groups (p > 0.05). As presented in **Table 2,** the thick phenotype group demonstrated significantly better esthetic outcomes than the thin phenotype group. The mean PES was higher in the thick phenotype group (12.6 ± 1.3 vs. 10.8 ± 1.5; p < 0.001), as was the mean WES (9.6 ± 1.2 vs. 8.7 ± 1.4; p = 0.001). The total PES/WES score was also significantly higher in the thick phenotype group (22.2 ± 2.1 vs. 19.5 ± 2.3; p < 0.001). Mid-facial mucosal recession was significantly lower in the thick phenotype group (0.34 ± 0.21 vs. 0.82 ± 0.35 mm; p < 0.001), while the papilla fill score was significantly higher (2.8 ± 0.4 vs. 2.1 ± 0.5; p < 0.001). **Table 3** presents the comparison of peri-implant clinical parameters and patient satisfaction. The thick phenotype group had significantly lower mean probing depth than the thin phenotype group (2.38 ± 0.39 vs. 2.62 ± 0.44 mm; p = 0.004) and a significantly greater width of keratinized mucosa (4.0 ± 0.9 vs. 2.7 ± 0.8 mm; p < 0.001). Patient satisfaction scores were also significantly higher in the thick phenotype group (9.3 ± 0.6 vs. 8.1 ± 0.9; p < 0.001). Differences in bleeding on probing (9.1% vs. 20.0%; p = 0.102) and prosthetic complications (3.6% vs. 10.9%; p = 0.143) were not statistically significant.

Table 1: Demographic and clinical characteristics of the study population

Variable	Thin Phenotype (n=55)	Thick Phenotype (n=55)	p-value
Mean age (years)	38.6 ± 9.2	40.1 ± 8.7	0.376
Male	28 (50.9%)	30 (54.5%)	0.706

Female	27 (49.1%)	25 (45.5%)	
Maxillary implants	41 (74.5%)	43 (78.2%)	0.648
Mandibular implants	14 (25.5%)	12 (21.8%)	
Immediate implant placement	20 (36.4%)	18 (32.7%)	0.683
Delayed implant placement	35 (63.6%)	37 (67.3%)	

Table 2: Comparison of esthetic outcomes between thin and thick soft tissue phenotypes

Clinical Parameter	Thin Phenotype (n=55)	Thick Phenotype (n=55)	p-value
Pink Esthetic Score (PES)	10.8 ± 1.5	12.6 ± 1.3	<0.001*
White Esthetic Score (WES)	8.7 ± 1.4	9.6 ± 1.2	0.001*
Total PES/WES Score	19.5 ± 2.3	22.2 ± 2.1	<0.001*
Mid-facial mucosal recession (mm)	0.82 ± 0.35	0.34 ± 0.21	<0.001*
Papilla Fill Score	2.1 ± 0.5	2.8 ± 0.4	<0.001*

**Statistically significant.*

Table 3: Comparison of peri-implant clinical parameters and patient satisfaction

Parameter	Thin Phenotype (n=55)	Thick Phenotype (n=55)	p-value
Probing depth (mm)	2.62 ± 0.44	2.38 ± 0.39	0.004*
Bleeding on probing (%)	11 (20.0%)	5 (9.1%)	0.102
Width of keratinized mucosa (mm)	2.7 ± 0.8	4.0 ± 0.9	<0.001*
Patient satisfaction (VAS, 0–10)	8.1 ± 0.9	9.3 ± 0.6	<0.001*
Prosthetic complications	6 (10.9%)	2 (3.6%)	0.143

**Statistically significant.*

Discussion:

This prospective comparative study aimed to assess the effects of the peri-implant soft tissue thickness on the esthetic outcomes of dental implants. Results showed that the thick peri-implant soft tissue phenotype had significantly higher pink esthetic scores (PES), white esthetic scores (WES), better papillary fill, less mid facial mucosal recession, more width of keratinized mucosa and higher degree of satisfaction among patients. Such observations support the fact that proper peri-implant mucosal thickness is a key factor for predicting the outcomes of esthetic and functional implant restorations. The peri-implant soft tissue characteristics have been studied by the researchers of Bonino *et al.* **[10]** who investigated the impact of these properties on clinician and patient outcomes in a prospective manner, revealing that soft tissue characteristics play a positive role in the peri-implant health and esthetic satisfaction assessment. The results of their study align with the present study, where patients were found to be more satisfied and have higher esthetic scores with the thicker peri-implant tissues. An adequate soft tissue volume helps to achieve a natural emergence profile, harmonious gingival contours and favours long-term tissue stability. In patients with thin tissue phenotypes, soft tissue augmentation is an important strategy to help improve aesthetics around implants. By thickening and obliterating underlying implant components and thereby altering or affecting peri-implant soft tissue contours, Chacón and Retana **[11]** showed that connective tissue grafts could aid in achieving esthetic outcomes in appeal and provide an increase in tissue thickness. Likewise, the present study has revealed that patients with naturally thick peri-implant mucosa have better esthetic outcomes, providing a biological benefit for thicker, soft tissue surface. Tavelli *et al.* in a systematic review and network meta-analysis, found that bilaminar techniques using connective tissue grafts or acellular dermal matrices increased peri-implant mucosal thickness, while apically positioned flap procedures combined with free gingival grafts were effective in increasing keratinized mucosa width. These findings support the potential role of phenotype modification when managing sites with inadequate peri-implant soft tissue dimensions **[12].** In their systematic review and network meta-analysis, Chambrone *et al.* **[13]** concluded that biologic materials and regenerative surgical techniques have an impact on clinical success and quality of soft tissues in periodontal and mucogingival surgery. While the present study did not investigate what biologic adjuncts would potentially be beneficial to dental implants, the outcomes were favourable in the thick phenotype group, suggesting similar clinical implications for increasing soft tissue thickness around a dental implant. Data from another thorough systematic review confirmed the results by Chambrone *et al.* **[14]** which stated that "Subepithelial connective tissue grafting continues to be the gold standard for augmentation of soft tissue and maintenance of esthetic stability." Sunitha *et al.* **[15]** reported significantly lower crestal bone loss and higher implant stability in patients with thicker mucosa than in those with thin mucosa over six months. Although their study focused on implant stability and crestal bone changes rather than esthetic scores, the findings provide additional evidence that peri-implant soft tissue thickness may influence clinical stability. With thicker, soft tissues, there is less margin loss and more soft tissue stability. The substantial differences observed in mid-facial recession in the thick phenotype group of the present study are consistent with these findings. Long term follow-up results by Eghbali *et al.* **[16]** showed that even after five years, there was a stable esthetic outcome that was achieved in combination with alveolar ridge preservation (ARP). They underlined good peri-implant soft tissue contour maintenance with good values of PES from the long term. The same was seen in the present study with a thicker peri-implant tissue exhibiting a significant higher PES score and better papillary architecture. Farooqui *et al.* **[17]** conducted a study on augmentation of peri-implant keratinized mucosa using free gingival grafts and collagen matrices and found significant changes in the soft tissue parameters and soft tissue health around the implant. In the present study, the duration of the patients' thick peri-implant tissues was significantly correlated with higher keratized mucosal width, indicating that maintenance and esthetic integration of peri-implant tissues are correlated with the keratinized mucosal width recorded. The choice of augmentation technique may influence the clinical outcome, as connective tissue grafts have shown advantages for increasing peri-implant soft-tissue thickness, whereas vestibuloplasty combined with a free gingival graft may be more effective for increasing keratinized mucosa width **[18]**. The value of esthetic assessment by Pink Esthetic Score was illustrated by Fürhauser *et al.* **[19]** who achieved consistent esthetic results 5 years after the placement of immediate implant restorations. Their work put PES on a sound objective basis for analysing peri-implant aesthetics. As per their observations the present study selected PES as one of the primary parameter and obtained a significant improvement in the patients with thick

soft tissue phenotypes. New digital technologies also have improved soft tissue care that surrounds implants. However, the relationship between peri-implant mucosal thickness and health may depend on the anatomical site and clinical context. Abu Hussien *et al.* (2023) reported an association between thicker palatal mucosa and deeper probing pockets and peri-implantitis, highlighting that tissue thickness alone may not uniformly indicate peri-implant health **[20].** Monaco *et al.* **[21]** showed that digital impressions of implants allow more precise representation of the peri-implant soft tissue contours, which increases the predictability of the prosthetic emergence profile and obtains a more favourable esthetic result. In the same way, Doliveux *et al.* **[22]** fabricated a personalized emergence profile through three dimensional printed casts for a higher accuracy reproduction of the peri-implant soft tissue structure during the elaboration of the prosthesis. In addition, digital methods for transferring subgingival contours were also created by Sasada *et al.* **[23]** and the use of intraoral scanners to precisely replicate the peri-implant soft tissue morphology in definitive restorations was introduced. Despite the fact that clinical outcomes were mainly assessed in the present study, these workflows could be more instrumental in maintaining and accurately matching peri-implant soft tissue contour during prosthetic rehabilitation to optimize the esthetic outcome. In summary, the data of the present study are consistent with the previously reported literature and confirm that peri-implant soft tissue thickness is an important factor in achieving esthetic success. Thick peri-implant mucosa is responsible for better soft tissue stability, shallower implant margins, improved papillary fill and higher patients' level of satisfaction. However, the careful analysis of the peri-implant phenotype at the time of treatment planning and the adequate soft tissue augmentation in thin phenotypes may yield better esthetic results with implant-supported restorations in the long term.

Conclusion:

Thick peri-implant mucosa was associated with better esthetic outcomes, including higher Pink and White Esthetic Scores, improved papillary fill and less mid-facial recession. Patients with thicker peri-implant tissues also exhibited greater keratinized mucosa width and higher satisfaction. Assessment of soft tissue phenotype and selective augmentation may help optimize long-term esthetic and clinical outcomes of implant-supported restorations.

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