

# Comparative Evaluation of Peri-Implant Soft Tissue Biotype as a Predictor of Crestal Bone Stability and Long-Term Implant Success: A Prospective Clinical Study

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## Abstract

**Background:** Peri-implant soft tissue biotype has been proposed as a significant determinant of crestal bone stability and long-term implant success. This prospective clinical study aimed to comparatively evaluate the influence of thin and thick mucosal phenotypes on implant stability and marginal bone preservation.

**Materials & Methods:** Thirty systemically healthy patients with mandibular first molar edentulism were divided into thin (<1 mm) and thick (1–2 mm) mucosal groups (n=15 each). Clinical parameters including mucosal thickness, implant stability (ISQ), bleeding on probing, and crestal bone levels were assessed at baseline, three months, and six months post-loading using standardized radiographic and clinical methods.

**Results:** At six months, the thick mucosa group demonstrated significantly greater implant stability (79.5 vs. 72.3 ISQ;  $p = 0.039$ ) and reduced crestal bone loss (0.70 mm vs. 1.60 mm;  $p = 0.004$ ) compared to the thin group. No significant intergroup differences were observed at baseline, and bleeding on probing was absent in all cases throughout the study period.

**Conclusion:** Thicker peri-implant mucosal phenotype was associated with enhanced implant stability and superior crestal bone preservation over time. Mucosal thickness may serve as a reliable predictor of peri-implant tissue stability and long-term implant prognosis.

**Key words:** Implants, Crestal, Bone

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## Introduction

Dental implants represent a widely accepted and predictable modality for the rehabilitation of partial and complete edentulism. Compared with conventional fixed partial dentures, implant-supported restorations

offer several clinical advantages, including long-term survival rates exceeding 97% over a 10-year period, reduced risk of caries and endodontic complications in adjacent teeth, preservation of alveolar bone at the edentulous site, and decreased hypersensitivity of

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neighboring dentition. Structurally, a dental implant is an alloplastic biomaterial placed beneath the mucosa and/or periosteum and/or within the osseous tissue to provide retention and support for fixed or removable prostheses.<sup>1, 2</sup> Technological advancements such as CAD/CAM systems, cone-beam computed tomography (CBCT), and three-dimensional printing have significantly enhanced diagnostic accuracy and surgical planning, enabling fabrication of patient-specific surgical guides that improve precision and reduce operative time and postoperative morbidity. Emerging integration of artificial intelligence and robotic-assisted systems further refines intraoperative accuracy through real-time feedback and adaptive control, although widespread implementation remains limited by cost, training requirements, and the need for long-term validation.<sup>3-5</sup>

From a biomaterial perspective, titanium continues to be the gold standard owing to its superior biocompatibility, corrosion resistance, and mechanical strength. Zirconia has emerged as an alternative in patients with metal hypersensitivity or high aesthetic demands, with encouraging short- and mid-term outcomes, though long-term equivalence to titanium requires further investigation. Despite these advances, implant therapy is still challenged by biological complications, particularly peri-implantitis, an inflammatory biofilm-associated condition that compromises osseointegration and long-term stability. Reported prevalence ranges from 10% to 50%, influenced by systemic health status, smoking habits, and oral hygiene practices. Innovations including antimicrobial surface coatings, bioactive implant modifications, and regenerative strategies involving growth factors and stem cell-based therapies show promise in mitigating these complications; however, standardized evidence-based clinical protocols are still evolving.<sup>6-8</sup> Hence; the present study was conducted for evaluating Peri-Implant Soft Tissue Biotype as a Predictor of Crestal Bone Stability and Long-Term Implant Success.

### Materials & methods

The present study was conducted for evaluating Peri-Implant Soft Tissue Biotype as a Predictor of Crestal Bone Stability and Long-Term Implant Success. 30 patients systemically healthy and aged 20–60 years with partial edentulism in the mandibular first molar region were included. Participants were categorized into two groups based on mucosal thickness: Group A (<1 mm, thin mucosa) and Group B (1–2 mm, thick mucosa), measured using a standardized K-file

technique at four reference points. Diagnostic casts were prepared, and CBCT imaging was performed for surgical planning. Prophylactic antibiotics were administered preoperatively. A customized surgical stent was fabricated on the diagnostic cast to guide implant positioning. During surgery, antiseptic preparation was followed by crestal incision and full-thickness flap elevation. Sequential osteotomy was performed. Standardized intraoral periapical radiographs using the paralleling technique and grid method were obtained to evaluate crestal bone levels at mesial and distal aspects. After three months, second-stage surgery was performed, healing abutments were placed, and platform-switching abutments were torqued according to manufacturer guidelines. Final impressions were made. Clinical parameters including mucosal thickness, bleeding on probing, implant stability, and crestal bone levels were assessed at baseline, three months, and six months post-loading. All the results were recorded in Microsoft excel sheet and were subjected to statistical analysis using SPSS software.

### Results

The study sample comprised 30 patients, with 18 males (60%) and 12 females (40%). The mean age was slightly higher in females (39.6 years) compared to males (37.8 years), indicating a comparable age distribution without marked demographic disparity between genders. At baseline, a clear difference in mucosal thickness was observed between the thin (0.90 mm) and thick (1.95 mm) mucosal groups ( $p = 0.001$ ). Implant stability at baseline was comparable between the two groups (55.8 vs. 57.2 ISQ;  $p = 0.240$ ), and crestal bone levels were identical (0.00 mm in both groups). At three months, implant stability improved in both groups (63.4 ISQ in thin and 66.1 ISQ in thick mucosa), although the intergroup difference remained statistically non-significant ( $p = 0.310$ ). Crestal bone loss was noted in both groups at three months (1.20 mm in thin vs. 0.80 mm in thick), but the difference did not reach statistical significance ( $p = 0.140$ ).

By six months post-prosthetic loading, stability further increased in both groups, with significantly higher stability in the thick mucosa group (79.5 vs. 72.3 ISQ;  $p = 0.039$ ). Crestal bone loss progressed in both groups but was significantly greater in the thin mucosa group (1.60 mm vs. 0.70 mm;  $p = 0.004$ ). Bleeding on probing was absent in all cases throughout the study period. Overall, while mucosal thickness remained consistently different between groups at all time points,

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its influence on implant stability and crestal bone preservation became statistically significant only at six months, with thick mucosa demonstrating superior peri-implant outcomes.

Table 1. Demographic Details of Study Sample

Parameter	Category	Male	Female
Gender	N (%)	18 (60%)	12 (40%)
Age (in years)	Mean	37.8	39.6

Table 2. Descriptive Analysis of Outcome Variables at Multiple Time Intervals

Time	Group	N	Mucosal Thickness (mm) Mean	Stability (ISQ) Mean	Crestal Bone Levels (mm) Mean	BO P Present	BO P Absent
Baseline	Thin	15	0.90	55.8	0.0	0	15
	Thick	15	1.95	57.2	0.0	0	15
3 Months	Thin	15	0.92	63.4	1.2	0	15
	Thick	15	1.97	66.1	0.8	0	15
6 Months	Thin	15	0.92	72.3	1.6	0	15
	Thick	15	1.97	79.5	0.7	0	15

Table 3. Intergroup Comparison of Outcome Variables

Time	Variable	Thin Mean	Thick Mean	p-value
Baseline	Mucosal Thickness (mm)	0.90	1.95	0.001*
	Stability (ISQ)	55.8	57.2	0.240
	Crestal Bone Levels (mm)	0.00	0.00	0.999

3 Months	Mucosal Thickness (mm)	0.92	1.97	0.001*
	Stability (ISQ)	63.4	66.1	0.310
	Crestal Bone Levels (mm)	1.20	0.80	0.140
6 Months	Mucosal Thickness (mm)	0.92	1.97	0.001*
	Stability (ISQ)	72.3	79.5	0.039*
	Crestal Bone Levels (mm)	1.60	0.70	0.004*

### Discussion

Dental implants have become the primary modality for replacement of missing teeth, functioning as artificial roots that support prostheses without involving adjacent sound dentition. Their long-term predictability is attributed to osseointegration and biologic compatibility, concepts established by Brånemark and further supported by functional ankylosis principles.<sup>6,7</sup> However, marginal crestal bone loss (CBL), particularly after abutment placement, remains a clinical concern, with studies reporting approximately 1.5 mm loss in the first year and minimal annual loss thereafter. Contributing factors include surgical trauma, stress concentration at the implant–abutment junction, microbial colonization of microgaps, establishment of biologic width, peri-implant inflammation, and prosthetic micromovements. To minimize CBL, various design modifications have been proposed, among which platform switching—using a narrower abutment to shift the implant–abutment junction medially—has shown promise in preserving marginal bone and enhancing esthetic outcomes. Additionally, peri-implant soft tissue thickness plays a crucial role in bone stability, with thicker mucosal phenotypes demonstrating improved crestal bone preservation and reduced recession; however, the precise interaction between soft tissue thickness and platform-switched abutments requires further clarification.<sup>8-10</sup> Hence; the present study was conducted for evaluating Peri-Implant Soft Tissue Biotype as a Predictor of Crestal Bone Stability and Long-Term Implant Success.

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In the present study, by six months post-prosthetic loading, stability further increased in both groups, with significantly higher stability in the thick mucosa group (79.5 vs. 72.3 ISQ;  $p = 0.039$ ). Crestal bone loss progressed in both groups but was significantly greater in the thin mucosa group (1.60 mm vs. 0.70 mm;  $p = 0.004$ ). Bleeding on probing was absent in all cases throughout the study period. Overall, while mucosal thickness remained consistently different between groups at all time points, its influence on implant stability and crestal bone preservation became statistically significant only at six months, with thick

mucosa demonstrating superior peri-implant outcomes. Tavelli et al. evaluated the long-term effectiveness of soft tissue augmentation procedures around dental implants, with particular emphasis on keratinized mucosa (KM), mucosal thickness (MT), and supracrestal tissue height (STH), while also assessing factors influencing marginal soft tissue stability over time. Through a narrative review of clinical and longitudinal investigations, they analyzed studies reporting extended follow-up outcomes of peri-implant soft tissue enhancement techniques. The evidence consistently indicates that a deficient peri-implant soft tissue phenotype—characterized by inadequate KM and reduced MT—is linked to higher susceptibility to inflammation, soft tissue recession, and marginal bone loss. Augmentation techniques such as autogenous free gingival grafts, connective tissue grafts, and biomaterial substitutes have demonstrated predictable and stable improvements in soft tissue contour, volume, and esthetic integration. Procedures designed to increase MT and STH, particularly bilaminar approaches, further contribute to sustained peri-implant tissue stability. Moreover, soft tissue augmentation has been shown to effectively manage peri-implant dehiscences and enhance papillary architecture, with documented stability extending up to 10 years. The review underscores the combined influence of KM, MT, and STH in maintaining peri-implant health and esthetics, highlighting the importance of phenotype-driven, individualized treatment planning.<sup>11</sup>

### Conclusion

Thick mucosal phenotype demonstrated significantly greater implant stability and reduced crestal bone loss at six months compared to thin mucosa. These findings suggest that mucosal thickness plays a crucial role in long-term peri-implant tissue preservation and overall implant prognosis.

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