Comparison of Soft Tissue Parameters Around Dental Implants and Tooth-Supported Fixed Partial Dentures: A 6-Month Split Mouth Study

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ABSTRACT

Introduction: Prosthetic rehabilitation largely depends on the condition of the surrounding soft tissues. Difference in the biological attachment mechanisms may influence soft tissue responses in implant-supported restorations and tooth-supported fixed partial dentures (FPDs). This study aims to compare peri-soft tissue parameters around implant-supported restorations and tooth-supported FPDs using clinical and cone-beam computed tomography (CBCT) assessments.

Methods: This prospective 6-month split-mouth clinical trial included 30 systemically healthy patients who required both a single dental implant (Group A) and a tooth-supported FPD (Group B).Plaque index, bleeding index, gingival recession, width of keratinised tissue, and esthetic score were recorded at baseline, 3 months, and 6 months following prosthetic loading. Gingival thickness and gingival biotype were evaluated using CBCT. Comparisons were performed using repeated measures ANOVA, unpaired t-tests and chi-square tests, with $p \leq 0.05$.

Results: Both groups showed a reduction in plaque index, although intragroup differences were not statistically significant. A significant intragroup change in bleeding index was observed in Group A. Gingival recession at 6 months was significantly lower in Group A compared to Group B ($p = 0.007$). No significant differences were found in keratinised tissue width or esthetic scores. Intergroup differences thickness was significant at 3 months at 2 mm level and at 6 months at 4 mm level. Gingival biotype remained stable.

Conclusion: Both implant-supported and tooth-supported restorations exhibited satisfactory peri-soft tissue health when appropriate surgical, prosthetic, and maintenance protocols were followed. Implant-supported sites showed greater stability of marginal soft tissues and distinct soft tissue remodelling.

Keywords: Cone-beam computed tomography; Dental implants; Fixed partial denture; Peri-implant soft tissue.

INTRODUCTION

The effectiveness of prosthetic rehabilitation in clinical settings is greatly affected by the condition of the soft tissues surrounding the prosthesis. Factors including the width of keratinised tissue, the position of the gingival margin, probing depth, and the integrity of the mucosa play a crucial role in aesthetics and the stability of peri-implant or periodontal

Conflict of Interest: None

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structures.[1] In cases of implants, the mucosa does not possess the periodontal ligament and the collagen fibres are oriented parallel to its surface, which influences the vascular supply and the resilience of the tissue.[2] In contrast, the periodontal environment in tooth-supported fixed partial dentures (FPDs) promotes positive soft tissue behaviour, due to the presence of natural periodontal ligament fibres.

METHODS

This prospective split-mouth clinical trial was registered with the Clinical Trials Registry of India (CTRI) with reference number CTRI/2025/09/094807 and approved by the Institutional Ethics Committee with reference number 05/IEC-SIBAR/CIR/25. The study was conducted in Sibar institute of dental sciences from January 2025 to November 2025 for a duration of 11 months. Written informed consent was obtained from all the participants prior to enrolment.

A total of 30 systemically healthy patients aged 18 years or older who required both a single dental implant and a tooth-supported fixed partial denture (FPD) in different quadrants were included in the study. The split-mouth design resulted in 30 implant-supported prosthetic sites (test group) and 30 tooth-supported FPD sites (control group), yielding a total of 60 evaluated sites. Convenience sampling was adopted, and eligible patients reporting to the outpatient department during the study period were recruited until the desired sample size was achieved. Systemically healthy patients aged 18 years or older who required both a single dental implant and a tooth-supported fixed partial denture (FPD) in different quadrants were included, while patients with uncontrolled systemic diseases, active periodontal disease, tobacco use, pregnancy or lactation, history of head and neck radiotherapy, or poor compliance were excluded.

Following initial full-mouth oral prophylaxis and standardised oral hygiene instructions, eligible patients were enrolled in a 6-month prospective split-mouth design, wherein implant-supported prostheses served as the test sites and tooth-supported FPDs served as the control sites, allowing intra-individual comparison of peri-soft tissue parameters while minimizing variability related to oral hygiene, systemic health, and individual tissue response.[3] Random allocation of test and control sites to the right or left side of the oral cavity was performed using a computer-generated randomisation sequence, and although operator blinding was not feasible due to the nature of the interventions, all clinical and radiographic outcome assessments were carried out by a blinded examiner to reduce measurement bias.[4]

Primary outcome measures included Plaque Index, Bleeding Index, gingival recession, width of keratinised tissue, and esthetic score. Plaque index was assessed using the Silness and Loe Plaque Index (1964) at four sites per tooth/implant (mesiobuccal, midbuccal, distobuccal, and palatal/lingual). Bleeding tendency was evaluated using the Modified Sulcus Bleeding Index (Mombelli et al., 1987) for implant sites, where probing was performed circumferentially at four sites using a standardized periodontal probe. At tooth-supported FPD sites, bleeding was assessed by gentle probing at four sites around the abutment teeth, and the presence or absence of bleeding within 10 seconds was recorded. Gingival recession was measured at the mid-buccal aspect using a UNC-15 periodontal probe; at FPD sites, measurements were taken from the cemento-enamel junction (CEJ) to the free gingival margin, whereas at implant sites, measurements were recorded from a fixed reference point on the prosthesis or implant shoulder to the mucosal margin. The width of keratinised tissue was measured at the mid-buccal aspect from the free gingival margin

to the mucogingival junction using the roll technique to identify the mucogingival junction. Esthetic evaluation was performed using the Pink Esthetic Score (PES) for implant-supported prostheses, while soft tissue esthetics around tooth-supported FPD sites were assessed using modified PES criteria adapted for natural teeth. while secondary outcome measures comprised of gingival thickness at 2 mm, gingival thickness at 4 mm and gingival biotype based on CBCT. All clinical and radiographic parameters were recorded at baseline, 3 months, and 6 months, with the placement of the definitive prosthesis (implant-supported crown or tooth-supported fixed partial denture) considered as the baseline time point. Pre-surgical clinical measurements were obtained using a standardised periodontal probe, with the width of keratinised tissue measured from the mucogingival junction to the free gingival margin, and soft tissue thickness assessed both clinically and radiographically using standardised CBCT imaging protocols at the planned implant sites.[5] At the test sites, dental implants were placed under local anaesthesia following a conventional two-stage surgical protocol in accordance to the manufacturer's guidelines, ensuring ideal three-dimensional positioning with respect to adjacent teeth and soft tissues. Primary wound closure was achieved, and an adequate healing period was allowed prior to second-stage surgery and prosthetic loading. Following osseointegration, implant-level impressions were made and definitive implant-supported crowns were fabricated and delivered. At the control sites, conventional tooth preparation for tooth-supported fixed partial dentures was performed with strict periodontal considerations, followed by placement of provisional restorations to allow soft tissue maturation, and subsequent cementation of definitive prostheses after achieving satisfactory marginal adaptation and tissue stability. Clinical and CBCT-based soft tissue measurements were subsequently recorded at 3 months and 6 months following prosthetic loading to assess temporal changes in peri-soft tissue parameters around both implant-supported and tooth-supported restorations.

Following placement of the definitive prosthesis at both test and control sites, standardised post-operative care instructions were provided to all patients. Participants were advised to avoid excessive masticatory forces on the restored sites for the initial 24–48 hours and to maintain meticulous oral hygiene practices. Mechanical plaque control was reinforced using a soft-bristled toothbrush, with additional instructions on the use of interproximal cleaning aids, including dental floss and interdental brushes, particularly around implant-supported crowns. Patients were instructed to use a non-alcoholic antimicrobial mouth rinse twice daily for a period of one week following crown placement. Occlusion was carefully evaluated and adjusted to eliminate premature contacts or excessive loading on the restorations. Patients were recalled at scheduled intervals for professional evaluation, reinforcement of oral hygiene instructions, and assessment of soft tissue healing. Any signs of discomfort, inflammation, or prosthesis-related complications were documented and managed accordingly. These standardised post-prosthetic care protocols were implemented uniformly across both implant-supported and tooth-supported restoration sites to minimize confounding variables during the follow-up period.

Post-surgical clinical and radiographic measurements were recorded after placement of the definitive prosthesis, which was considered the baseline time point. All parameters were subsequently reassessed at 3 months and 6 months following prosthetic loading to evaluate temporal changes in peri-soft tissue health. Clinical measurements, including probing depth, width of keratinised tissue, gingival or mucosal margin level, and plaque index were recorded

using a standardised periodontal probe under controlled probing force. Soft tissue thickness was assessed clinically and supplemented with cone-beam computed tomography (CBCT) imaging using standardised acquisition protocols to ensure reproducibility. All measurements were performed by a single calibrated examiner to minimise inter-examiner variability, and the same reference points were used at each follow-up visit for consistency.

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software, version 25.0 (IBM Corp., Armonk, NY, USA). The collected data were compiled with all continuous variables expressed as mean ± standard deviation. Data normality was assessed prior to inferential analysis. Intragroup comparisons of clinical, esthetic, and CBCT-based soft tissue parameters at baseline, 3 months, and 6 months within each group were performed using repeated measures analysis of variance (ANOVA), and when statistically significant differences were observed, post hoc pairwise comparisons with Bonferroni correction were applied to identify differences between specific time intervals. Intergroup comparisons between Group A (implant-supported restorations) and Group B (tooth-supported fixed partial dentures) at corresponding time points were carried out using the unpaired t-test for gingival thickness and chi square test for esthetic score. A p value of ≤ 0.05 was considered statistically significant for all analysis.

RESULTS

Initially, a total of 30 patients were assessed for eligibility, all of whom fulfilled the inclusion criteria and were enrolled in the study. The participants were randomly allocated in a split-mouth design, wherein each patient received an implant-supported prosthesis at one site (test site) and a tooth-supported fixed partial denture at the contralateral site (control site). During the follow-up period, two implant sites were lost to follow-up at 6 months and one tooth-supported FPD site was lost to follow-up after 3 months. The process of patient enrolment, randomisation, allocation, follow-up, and analysis is illustrated in the flow diagram (Figure 1).

Plaque Index

Both Group A and Group B showed a decrease in the plaque index from baseline to three and six months, as seen in Table 1, but the intragroup changes were not statistically significant. Group A had a considerably lower plaque index than Group B at baseline ($p = 0.002$), according to intergroup comparison (Table 2), but there were no statistically significant differences between the groups after three months ($p = 0.670$) or six months ($p = 0.327$).

Bleeding Index

Table 1 indicates that Group A's bleeding index changed statistically significantly within the group over time, but Group B's intragroup variance was not statistically significant. Group A had a considerably decreased bleeding index at baseline ($p = 0.014$), according to intergroup analysis (Table 2); however, at three months ($p = 0.670$) and six months ($p = 0.150$), there were no significant differences between the groups.

Gingival Recession

Gingival recession changed statistically significantly over time in Group A, according to an intragroup comparison (Table 1), whereas there was no discernible intragroup change in Group B. At baseline ($p = 0.573$) and three months ($p = 0.401$), the intergroup comparison (Table 2) revealed no significant difference between the groups; however, at six months, gingival recession was considerably smaller in Group A than in Group B ($p = 0.007$).

Keratinised Tissue Width

As presented in Table 1, no statistically significant intragroup changes in keratinised

tissue width were observed over time in either group. Intergroup comparison (Table 2) also revealed no statistically significant differences between Group A and Group B at baseline (p = 0.822), 3 months (p = 0.315), or 6 months (p = 0.535).

Esthetic Score

Intragroup analysis (Table 1) showed no statistically significant changes in esthetic scores across all time intervals in either group. Similarly, intergroup comparison (Table 2) demonstrated no statistically significant differences in esthetic scores between Group A and Group B at baseline (p = 0.114), 3 months (p = 0.559), or 6 months (p = 0.295).

Repeated measures ANOVA demonstrated a statistically significant increase in GT at 2 mm over time in both groups, indicating progressive soft tissue thickening during the follow-up period, whereas GT at 4 mm showed a significant change only in Group A, with no significant temporal variation observed in Group B as shown in Table 3. The distribution of gingival biotype within each group remained relatively stable from baseline to 6 months, suggesting that the surgical and prosthetic interventions did not adversely influence biotype conversion during the observation period.

The intergroup comparison of CBCT-based parameters between Group A and Group B at baseline, 3 months, and 6 months has been tabulated in Table 4. No statistically significant differences were observed between the groups at baseline for GT at either 2 mm or 4 mm, confirming baseline comparability. At 3 months, a significant intergroup difference was noted for GT at 2 mm, while at 6 months a significant difference was observed for GT at 4 mm, indicating differential soft tissue remodeling patterns between implant-supported and tooth-supported sites over time. However, gingival biotype distribution did not differ significantly between the two groups at any time point, suggesting comparable soft tissue phenotype outcomes for both treatment modalities.

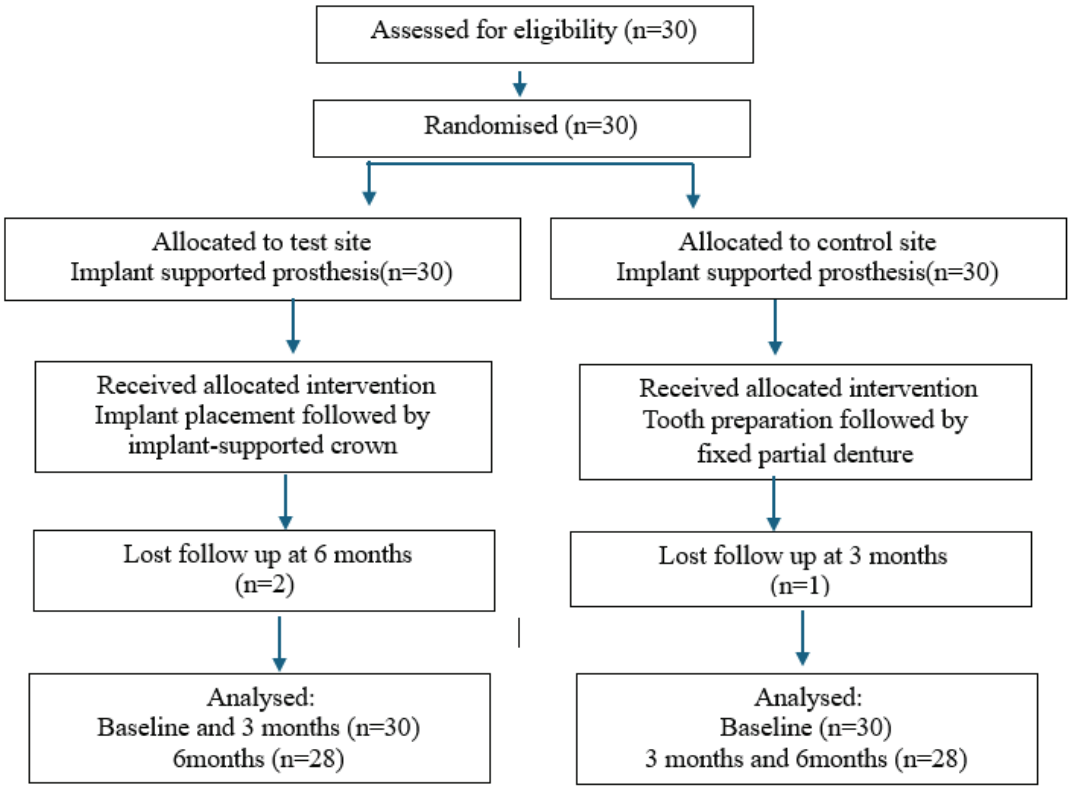

Figure 1: *Randomisation, allocation and follow-up of the participants.*

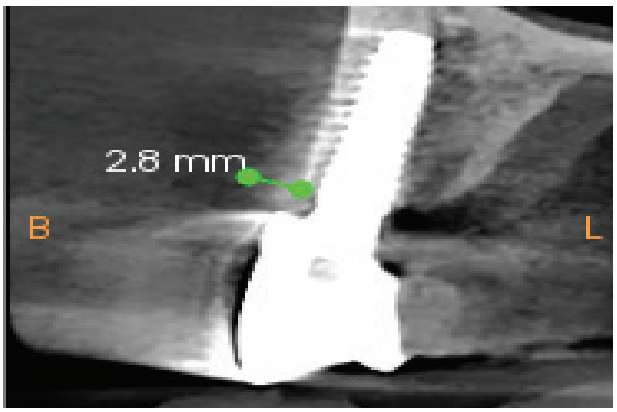

Figure 2: Measurement of recession at a depth of 2 mm in the mid-facial aspect using a customised acrylic stent and a UNC-15 periodontal probe at 6 months.

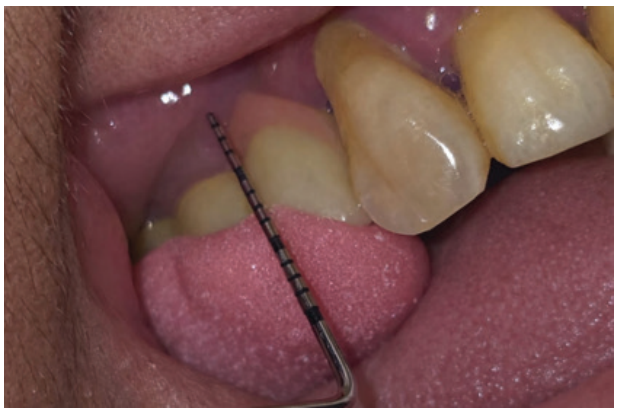

Figure 3:. Peri-implant soft tissue thickness in CBCT measured perpendicular to the long axis of the implant from the buccal bone crest to the outer soft tissue contour.

Table 1: Intragroup comparison of plaque index, bleeding index, gingival recession, keratinised tissue width and esthetic score.

Site	Time	Plaque Index	Bleeding Index	Gingival recession	Keratinised tissue width	Esthetic score
Group - A	Baseline	1.33 ± 0.33	0.44 ± 0.22	0.50 ± 0.06 mm	4.20 ± 0.09 mm	8.75 ± 0.09
	3 months	1.25 ± 0.36	0.48 ± 0.28	0.67 ± 0.26 mm	4.06 ± 0.11 mm	8.81 ± 0.11
	6 months	1.16 ± 0.35	0.64 ± 0.24	0.43 ± 0.05 mm	3.96 ± 0.11 mm	8.74 ± 0.14
	p value	0.123	**0.003***	**<0.001***	0.369	0.922
	Δ1 p value	0.074 (p=1.000)	−0.043 (p=1.000)	−0.171 (p=1.000)	0.134 (p=1.000)	-0.055 (p=1.000)
	Δ2 p value	0.170 (p=0.116)	−0.203 (p=0.005*)	0.069 (p=1.000)	0.239 (p=0.468)	0.014 (p=1.000)
	Δ3 P value	−0.096 (p=0.796)	0.161 (p=0.040*)	−0.241 (p=1.000)	−0.106 (p=1.000)	−0.069 (p=1.000)
Group - B	Baseline	1.76 ± 0.91	0.79 ± 0.32	0.73 ± 0.06 mm	3.65 ± 0.10 mm	8.06 ± 0.12
	3 months	1.60 ± 0.07	0.88 ± 0.29	0.59 ± 0.07 mm	3.58 ± 0.13 mm	7.76 ± 0.13
	6 months	1.77 ± 0.80	0.98 ± 1.59	0.73 ± 0.12 mm	3.16 ± 0.16 mm	7.79 ± 0.12
	p value	0.248	0.469	0.400	0.917	0.238
	Δ1 p value	0.163 (p=0.559)	−0.092 (P=0.765)	0.143 (p=0.556)	0.065 (p=1.000)	0.294 (p=0.501)
	Δ2 p value	−0.012 (p=1.000)	−0.193 (p=1.000)	−0.001 (p=1.000)	0.037 (p=1.000)	0.271 (p=0.357)
	Δ3 p value	0.175 (p=0.339)				

* indicates statistical significance.

Table 2: Intergroup comparison of plaque index, bleeding index, gingival recession, keratinised tissue width and esthetic score between group A and Group B.

Time	Plaque Index (p value)	Bleeding Index (p value)	Gingival recessions (p value)	Keratinised tissue width (p value)	Esthetic score (p value)
Baseline	**0.002***	**0.014***	0.573	0.822	0.114
3 months	0.670	0.670	0.401	0.315	0.559
6 months	**0.327**	**0.150**	**0.007***	**0.535**	**0.295**

* indicates statistical significance.

Table 3: Intragroup comparison of gingival thickness at 2 mm, gingival thickness at 4mm and gingival biotype in CBCT.

Site	Time	Gingival thickness at 2 mm	Gingival thickness at 4 mm	Gingival biotype (n)
Group - A	Baseline	1.11 ± 0.94 mm	1.41 ± 0.11 mm	Thick: 13 / Thin: 16
	3 months	1.18 ± 0.11 mm	1.33 ± 0.14 mm	Thick: 15 / Thin: 14
	6 months	1.32 ± 0.33 mm	1.37 ± 0.14 mm	Thick: 15 / Thin: 14
	p value	**0.000***	**0.031***	0.293
	Δ1 p value	**0.000***	0.058	NA
	Δ2 p value	**0.009***	0.536	NA
	Δ3 p value	0.055	0.095	NA
Group - B	Baseline	1.18 ± 0.75	1.50 ± 0.83	Thick: 17 / Thin: 12
	3 months	1.20 ± 0.08	1.37 ± 0.38	Thick: 17 / Thin: 12
	6 months	1.27 ± 0.13	1.46 ± 0.10	Thick: 17 / Thin: 12
	p value	0.014*	0.189	0.597
	Δ1 p value	0.992	0.349	NA
	Δ2 p value	**0.009***	0.483	NA
	Δ3 p value	0.021*	0.643	NA

* indicates statistical significance.

Δ1: Baseline to 3 months; Δ2: Baseline to 6 months; Δ3: 3 to 6 months; NA: Not applicable.

Table 4: Intergroup comparison of gingival thickness at 2 mm, gingival thickness at 4mm and gingival biotype in CBCT.

Time	Gingival thickness at 2mm (p value)	Gingival thickness at 4mm (p value)	Gingival Biotype (p value)
Baseline	0.311	0.08	0.293
3 months	0.040*	0.213	0.597
6 months	0.371	0.028*	0.597

* indicates statistical significance.

DISCUSSION

The long-term success of both implant-supported restorations and tooth-supported fixed partial dentures is closely associated with the health and stability of the surrounding peri-soft tissues. In the present split-mouth study, clinical periodontal parameters and CBCT-derived soft tissue measurements were evaluated to elucidate differences in soft tissue behaviour between implant-supported and tooth-supported restorations under comparable intra-individual conditions. The split-mouth design minimised confounding variables such as oral hygiene practices, systemic health, and host response, thereby strengthening the validity of the comparisons.

Plaque index values demonstrated a gradual reduction over time in both groups, reflecting effective plaque control following prosthetic rehabilitation and reinforcement of oral hygiene measures. Although implants lack a periodontal ligament and associated vascular supply, comparable plaque scores between the two groups suggest that meticulous maintenance can achieve satisfactory plaque control around both implant-supported and tooth-supported restorations, as supported by previous reports.[1,6] However, the clinical significance of plaque accumulation may differ, as peri-implant tissues are known to exhibit a heightened inflammatory response compared to periodontal tissues.[7]

Bleeding index values showed a significant intragroup reduction over the follow-up period in the implant group, indicating improvement in peri-implant mucosal health following prosthetic loading. This finding may be attributed to improved tissue maturation and stabilization after the healing phase. Similar observations have been reported in earlier studies emphasizing the importance of adequate peri-implant soft tissue conditions in maintaining peri-implant health.[8,9] In contrast, the tooth-supported FPD group exhibited relatively stable bleeding scores, likely due to the presence of a functional periodontal ligament and a well-established supracrestal tissue attachment.[10]

Gingival recession demonstrated differing trends between the two groups, with implant-supported sites showing more stable marginal tissue levels over time compared to tooth-supported sites. This may be explained by differences in soft tissue attachment, as collagen fibers around implants are oriented parallel to the implant surface, whereas perpendicular fiber insertion around natural teeth provides enhanced resistance to apical migration of the gingival margin.[11] Nonetheless, proper prosthetic contouring and controlled occlusal loading appear to play a crucial role in maintaining marginal tissuestability around both treatment modalities.

Keratinised tissue width did not demonstrate significant intergroup differences across the evaluation periods, supporting previous findings that the presence of an adequate band of keratinised tissue, rather than its absolute width, may be more critical for patient comfort and plaque control.[7,8,9] Although the necessity of keratinised mucosa around implants remains debated, several studies have suggested that insufficient keratinised tissue may predispose peri-implant tissues to inflammation, particularly in patients with suboptimal oral hygiene.[8]

The CBCT-based assessment of gingival thickness provided additional insight into soft tissue remodeling patterns. Intragroup analysis revealed a significant increase in gingival thickness at 2 mm from the crest in both groups, indicating favorable soft tissue adaptation following prosthetic loading. These findings are consistent with recent studies demonstrating that CBCT can reliably quantify peri-soft tissue dimensions and detect subtle volumetric changes over time.[12,3,14] At the 4 mm level, significant changes were observed primarily in the implant group, suggesting a more pronounced soft tissue remodeling response around implant-supported restorations.

Intergroup CBCT comparisons revealed significant differences at select time points, highlighting distinct biological responses of peri-implant and periodontal tissues. Despite these variations, gingival biotype distribution remained comparable between the two groups throughout the study period, indicating that neither treatment modality adversely influenced soft tissue phenotype conversion. This observation aligns with previous reports suggesting that gingival biotype is largely determined by patient-specific factors rather than restorative type alone.[15,16]

Overall, the combined clinical and CBCT findings of the present study underscore that both implant-supported and tooth-supported restorations can achieve favorable peri-soft tissue outcomes when appropriate surgical, prosthetic, and maintenance protocols are followed. The adjunctive use of CBCT enhances the understanding of soft tissue dynamics and may aid clinicians in evidence-based treatment planning and long-term maintenance strategies.

Our results are consistent with recent data showing that the presence of adequate soft tissue dimensions—including keratinised mucosa and thickness—can play a protective role in peri-implant health.[1,17] A systematic review found that implants with ≥2 mm of keratinised tissue exhibited less bleeding on probing, less plaque accumulation, and reduced gingival recession

compared to those with inadequate keratinised tissue.[17] Conversely, some observational studies have suggested that when meticulous oral hygiene is maintained, marginal soft tissue parameters may remain stable even in the absence of large zones of keratinised tissue, highlighting the multifactorial nature of peri-implant tissue health.[1,5]

Data on soft tissue thickness and esthetic outcomes further emphasize that thicker peri-implant mucosa is related to more favorable esthetic and biological results, including reduced risk of recession and better emergence profile preservation.[15] Although our study did not examine long-term outcomes beyond 6 months, the observed increases in gingival thickness in both groups may contribute to improved soft tissue resilience over time.

These findings suggest that clinicians should consider both clinical periodontal indices and soft tissue morphometry when planning treatment. Soft tissue augmentation or grafting procedures (e.g., connective tissue grafts or PRF) may be indicated in sites with thin biotypes to enhance peri-implant soft tissue stability and esthetics.[12,18] Additionally, consistent maintenance and hygiene protocols remain crucial to optimize outcomes in both implant and tooth-supported restorations.

The study's 6-month duration limits interpretation of long-term soft tissue behavior. Future studies with extended follow-up and larger sample sizes are required to elucidate the sustained impact of soft tissue thickness and keratinised tissue on hard and soft tissue health around different prosthetic restorations. Additionally, histological correlation and assessment of patient-reported esthetic outcomes may further strengthen the clinical applicability of these findings.

CONCLUSION

Within the limitations of this 6-month split-mouth study, both implant-supported and tooth-supported fixed partial dentures demonstrated satisfactory peri-soft tissue health. Implant-supported sites showed significantly less gingival recession at 6 months and distinct soft tissue remodelling patterns, particularly in gingival thickness. However, plaque levels, keratinised tissue width, aesthetic scores, and gingival biotype remained comparable between the two groups. Proper surgical technique, prosthetic design, and maintenance were critical in maintaining soft tissue stability in both treatment modalities.

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