ISSN: 3062-3405

Annals of Orthodontics and Periodontics Specialty
Volume 3, Page No: 43-51
Available Online at: aopsj.com

Original Article

Investigation of Soft Tissue Outcomes in Posterior Implant Placement Using Minimally Invasive Methods: A Clinico-Radiographic Study

Romano Giorgia[1*], Costa Mattia[1]

1. Department of Head and Neck, Oral Surgery, and Implantology Unit, Institute of Clinical Dentistry, Fondazione Policlinico Universitario A. Gemelli IRCCS - Università Cattolica del Sacro Cuore, Rome, Italy.

***E-mail** ✉ romano.g@outlook.com

Abstract

Forecasting alterations in both hard and soft peri-implant tissues following immediate or delayed implant placement is essential, since poor prediction can result in biological and esthetic failures that may compromise long-term implant success. The present investigation aimed to analyze and contrast hard- and soft-tissue responses in immediately and delay-placed posterior implants inserted through a flapless surgical protocol. A total of 46 participants who required implant therapy in the posterior region (premolar or molar areas) were selected and randomly divided into two equal groups. Group 1 received immediate implants, while Group 2 underwent delayed placement. Clinical indices such as plaque index (PI), gingival index, modified sulcus bleeding index, probing depth, and Testori esthetic score (TS) were recorded at baseline, 3, 6, 9, and 12 months. Radiographic assessment using cone-beam computed tomography (CBCT) was performed at baseline and after 12 months to evaluate buccal bone thickness (BBT), crestal bone height (CBH), and ridge width. Intragroup comparisons indicated statistically significant time-dependent changes in PI, probing pocket depth, and TS ($P = 0.00$) in both groups. The average BBT at the crest in delayed implants (1.76 ± 0.24) showed a notable reduction after 12 months compared with the immediate group. Both groups demonstrated a marked increase in TS scores at 12 months. After 12 months, a significant difference in TS was observed between the two groups, revealing superior esthetic outcomes for immediate implants. However, BBT and CBH remained largely unchanged over the same period in Group 1.

Key words: Immediate implants, Delayed placement, Flapless surgery, Peri-implant tissues

How to cite this article: Giorgia R, Mattia C. Investigation of Soft Tissue Outcomes in Posterior Implant Placement Using Minimally Invasive Methods: A Clinico-Radiographic Study. Ann Orthod Periodontics Spec. 2023;3:43-51. https://doi.org/10.51847/oys4eD0kKi

Introduction

Dental implants have become a reliable option for restoring missing teeth, providing both functional efficiency and esthetic harmony. Although the predictability of osseointegrated implants is high, biological or mechanical stress may lead to complications such as peri-implantitis or crestal bone resorption, resulting in marginal bone loss. Therefore, maintaining bone and soft-tissue integrity has become critical for esthetic success.

Placing an implant immediately after extraction can benefit both clinician and patient by reducing total treatment time, limiting bone resorption, and enhancing esthetics. Nevertheless, this protocol often leaves a gap between the implant and

socket wall, which can trap contaminants, raising infection risks and the likelihood of implant failure. To overcome this, delaying the placement by 6–8 weeks allows soft tissues to heal and minimizes postoperative complications.
Using a flapless surgical method provides several clinical advantages: reduced tissue trauma, preservation of the periosteal blood supply, less bleeding, rapid epithelial recovery without sutures, shorter operative time, and greater patient comfort and acceptance.
As reported by Novaes *et al.*, the microarchitecture and vascularity of the bone crest strongly affect the remodeling phase that follows implant insertion [1]. Evidence from earlier work indicates that flapless surgery enhances mucosal vascularization and improves the local blood supply, possibly increasing the implant's resistance to inflammation [2, 3]. Hence, the study hypothesized that delayed flapless implants would exhibit minimal hard- and soft-tissue alterations compared with immediate flapless implants, based on clinical and CBCT assessments. Despite growing interest, few in vivo studies have simultaneously investigated these outcomes for posterior implants using a flapless approach. Furthermore, understanding tissue behavior—including papilla fill, color, contour, and texture—around both types of implants remains limited. Consequently, this study aimed to comprehensively compare these variables both clinically and radiographically in posterior flapless implant placements.

Materials and Methods

This clinical trial was undertaken in the Department of Periodontology and Implant Dentistry at the authors' institution. Ethical approval was granted by the Institutional Review Board, adhering to the revised Helsinki Declaration for biomedical research. The trial was also registered in the Clinical Trials Registry of India (CTRI/2020/04/024591) and followed the CONSORT and EQUATOR reporting standards. All participants signed written informed consent before participation.
Sample size estimation was based on Edward *et al.* [4], considering the mean peri-implant bone density gray scale after 6 months, with a 99% confidence level and 80% statistical power. Thus, a minimum of 17 implants per group was determined.
Eligible subjects were systemically healthy adults aged ≥21 years, presenting with stable soft-tissue conditions and able to achieve a minimum insertion torque of 35 Ncm. Criteria for delayed implants included partially edentulous posterior maxillary or mandibular sites with sufficient bone (native or grafted) to accommodate implants. Criteria for immediate placement comprised teeth indicated for extraction due to Grade I–II mobility, root remnants, endodontic failure, non-restorable caries, or irreversible periapical pathology, such as vertical root fracture or advanced periodontal disease rendering the tooth hopeless.

Exclusion criteria
Participants were not considered eligible if they had undergone radiation therapy to the head or neck within the preceding six months, were receiving or had received intravenous aminobisphosphonates, had any systemic disorders, were pregnant or nursing, used tobacco, exhibited parafunctional oral behaviors, or presented with unsatisfactory oral hygiene.
To accommodate potential dropouts, a total of 23 subjects per group were enrolled. Implant sites that fulfilled the inclusion requirements were divided as follows:
Group I: Immediate implant (**n = 23**)
Group II: Delayed implant (**n = 23**)

Preoperative and baseline procedures
At the start, all participants received personalized oral hygiene guidance followed by professional cleaning. Prior to surgical procedures, baseline CBCT imaging, hematological analyses, and diagnostic models were obtained. To ensure uniformity in data collection, occlusal stents were fabricated from cold-cured acrylic resin, covering the occlusal surface of the planned implant-supported crown as well as one tooth anteriorly and posteriorly. The appliances extended apically on both buccal and lingual sides, protecting the coronal one-third of the tooth. Each stent contained a reference groove to maintain a consistent probe location during subsequent evaluations.

Clinical measures, including plaque index (PI) [5], gingival index (GI) [6], modified sulcus bleeding index (mSBI) [7], and probing depth (PD), were recorded at baseline, and at 3, 6, 9, and 12 months after surgery. A single calibrated clinician (PB) collected the data prior to surgery. The outcome assessor (AK), unaware of group allocation, performed postoperative evaluations. Each measurement was repeated at two different intervals, and intraobserver consistency was quantified using the intraclass correlation coefficient (ICC).

Soft tissue evaluation around implants

Assessment of peri-implant soft tissue included observation of mesial and distal papilla presence and stability, tissue surface characteristics, color tone, and gingival contouring. Scoring was based on Testori *et al.*'s criteria [8] (TS). Any recession or variation of the midfacial mucosal margin was recorded at all time points.

1. **TS (a) Papillary presence and stability:**
   i. **0** – No papilla visible
   ii. **1** – Incomplete fill but aesthetically satisfactory
   iii. **2** – Complete fill of the interdental space

Papillary dimensional changes were determined by measuring the vertical distance between the papilla tip (mesial or distal) and a reference line joining the CEJs of the neighboring teeth, repeated at regular intervals.

2. TS (b) Tissue surface texture:
   i. **0** – Total absence of surface texture
   ii. **1** – Partial preservation, not fully normal
   iii. **2** – Comparable to the natural gingiva adjacent to teeth

3. TS (c) Tissue coloration:
   i. **0** – Completely mismatched with normal gingival color
   ii. **1** – Slightly different but still acceptable
   iii. **2** – Similar to healthy gingiva around natural teeth

4. TS (d) Gingival form and contour:
   i. **0** – Pronounced irregularity in contour
   ii. **1** – Minor deviation yet esthetically tolerable
   iii. **2** – Balanced and natural scalloping pattern

Radiographic analysis

Imaging assessments were performed via CBCT at baseline and 12 months, and by radiovisiography (RVG) at 3, 6, and 9 months **(Figure 1)**.

1. Buccal Bone Thickness (BBT):

Measured at the crest, 2 mm below the crest, mid-implant, and apical areas on CBCT at baseline and 12 months after placement.

2. Crestal Bone Height (CBH):

The distance from the CEJ or implant shoulder to the most coronal point of interproximal bone was evaluated through CBCT at baseline and 12 months, and RVG at 3, 6, and 9 months.

3. Ridge Width (RW):

The buccolingual ridge dimension was analyzed using CBCT at baseline and 12 months, and clinically with a bone caliper at 3, 6, and 9 months post-surgery.

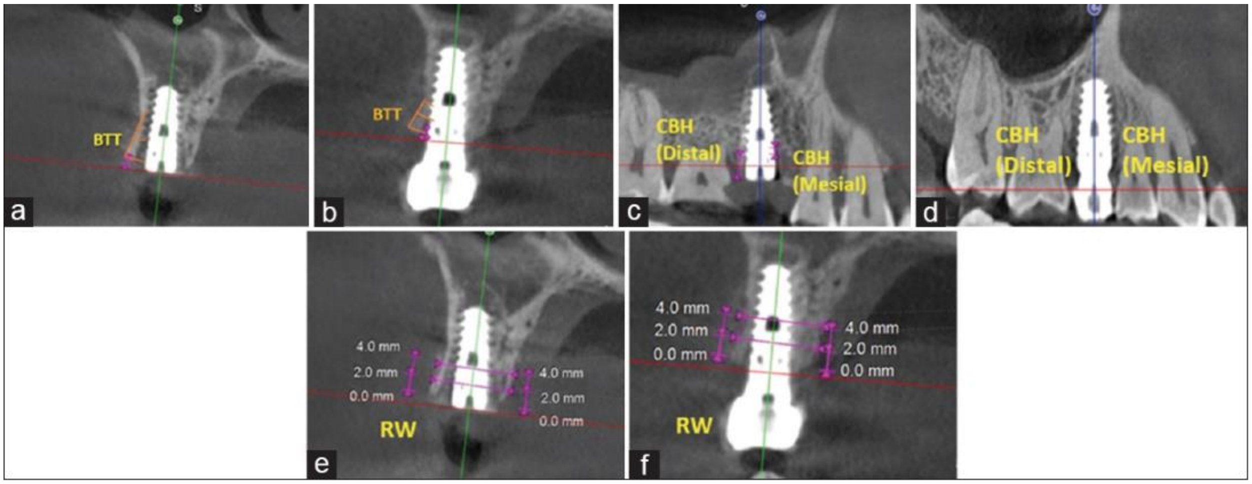

Figure 1. (a, b) Buccal bone thickness at baseline and 12 months; (c, d) Crestal bone height at mesial and distal surfaces at baseline and 12 months; (e, f) Ridge width comparison between baseline and 12 months.
Abbreviations: BBT – Buccal Bone Thickness; CBH – Crestal Bone Height; RW – Ridge Width; mm – millimeters.

The osteotomy and subsequent implant placements were executed with the aid of patient-specific drilling templates, designed to match implant dimensions, in accordance with the manufacturer's clinical guidelines for both study groups **(Figure 2**). Following surgery, all participants were prescribed appropriate antibiotics and pain relief medication. Clinical assessments were performed at 3, 6, 9, and 12 months postoperatively, whereas radiographic evaluation using CBCT was conducted initially and again one year after the procedure.

Figure 2. (a–c) Immediate flapless implant placement (Group 1); (d–f) Delayed flapless implant placement (Group 2)

After data acquisition, statistical computations were carried out using SPSS software version 26.0 (IBM Corp., USA). Participant demographics, including age and gender, were summarized according to variable type. Data distribution was inspected for normality through both visual assessment and the Shapiro–Wilk test. The mean ages of the two treatment groups were compared by applying an independent-samples t-test. Variables such as PI, GI, mSBI, PD, TS, BBT, CBH, and RW were expressed as mean values with standard deviations. Intergroup differences were analyzed using the t-test for independent samples, and changes in PI, GI, mSBI, PD, and TS over multiple time intervals were evaluated using Friedman ANOVA, with a 5% threshold for statistical significance.

Results

All 46 participants successfully completed the follow-up period with 100% implant survival, ensuring full inclusion in the analysis. The mean age of Group 1 subjects was 41.33 ± 11.6 years, while Group 2 participants averaged 42.6 ± 12.22 years. Descriptive data for PI, GI, mSBI, PD, and TS across various time intervals are presented in **Table 1**.

In Group 1, the mean PI dropped from 1.45 ± 0.52 at baseline to 0.14 ± 0.50 after 12 months, whereas Group 2 demonstrated a reduction from 1.08 ± 0.00 to 0.55 ± 0.52. Statistically significant differences were recorded for PI, GI, and PD from baseline to 12 months in both cohorts.

Soft tissue variations were quantified using the TS index. A highly significant temporal change (P = 0.000) was observed in the mesiodistal papilla parameter, while the color and texture of the peri-implant mucosa remained largely unchanged. Mean gingival contour (TS [d]) scores rose from 0.55 ± 0.52 to 1.55 ± 0.52 in Group 1 and from 0.00 ± 0.00 to 1.45 ± 0.52 in Group 2, with both improvements being statistically highly significant (P = 0.000).

Table 1. Intragroup evaluation of PI, GI, mSBI, PD, and TS across different intervals in Group 1 and Group 2

Intragroup Comparison in Group 1	**Baseline**	**3 Months**	**6 Months**	**9 Months**	**12 Months**	**P**
Plaque Index (PI)	1.45±0.52	0.55±0.52	0.27±0.46	0.15±0.52	0.14±0.50	0.000**
Gingival Index (GI)	1.7±0.25	1.4±0.29	1.35±0.22	1.34±0.21	1.31±0.24	0.037*
Modified Sulcular Bleeding Index (mSBI)	1.0±0.71	0.86±0.71	0.83±0.69	0.82±0.64	0.85±0.74	0.071
Probing Depth (PD, mm)	2.78±0.50	2.25±0.52	2.35±0.52	2.15±0.52	2.05±0.5	0.000**
Tooth Staining (TS) (a)	0.00±0.00	0.00±0.00	1.09±0.83	1.09±0.83	1.09±0.83	0.000**
Tooth Staining (TS) (b)	1.55±0.52	1.55±0.52	1.82±0.40	1.82±0.40	1.55±0.52	0.381
Tooth Staining (TS) (c)	1.55±0.52	1.55±0.52	1.64±0.50	1.64±0.50	1.55±0.52	0.981
Tooth Staining (TS) (d)	0.55±0.52	0.55±0.52	1.75±0.46	1.82±0.40	1.55±0.52	0.000**
Total Tooth Staining (TS)	0.90±0.16	0.90±0.16	1.81±0.40	1.59±0.45	1.43±0.38	0.000**
Intragroup Comparison in Group 2	**Baseline**	**3 Months**	**6 Months**	**9 Months**	**12 Months**	**P**
Plaque Index (PI)	1.08±0.00	0.55±0.52	0.45±0.00	0.64±0.50	0.55±0.52	0.000**
Gingival Index (GI)	1.04±0.21	1.2±0.19	1.34±0.21	1.30±0.23	1.21±0.24	0.036*
Modified Sulcular Bleeding Index (mSBI)	1.57±0.71	1.46±0.45	1.28±0.19	0.96±0.62	0.94±0.54	0.071
Probing Depth (PD, mm)	0.00±0.00	2.18±0.60	2.18±0.60	2.18±0.60	2.18±0.60	0.000**
Tooth Staining (TS) (a)	0.00±0.00	0.00±0.00	1.36±0.50	1.45±0.52	1.36±0.50	0.000**
Tooth Staining (TS) (b)	1.45±0.52	1.45±0.52	1.82±0.40	1.82±0.40	1.64±5.0	0.186
Tooth Staining (TS) (c)	1.73±0.46	1.73±0.46	1.91±0.30	1.91±0.30	1.82±0.405	0.678
Tooth Staining (TS) (d)	0.00±0.00	0.00±0.00	1.82±0.16	2.00±0.00	1.45±0.52	0.000**
Total Tooth Staining (TS)	0.79±0.15	0.79±0.15	2.00±0.00	1.79±0.18	1.56±0.29	0.000**

*Significant (p<0.05); **Highly significant (p<0.001).*

PI – Plaque index; GI – Gingival index; mSBI – Modified sulcus bleeding index; PD – Probing depth; TS – Testori score;

TS (a) – Papilla presence and stability; TS (b) – Soft-tissue texture; TS (c) – Soft-tissue color; TS (d) – Gingival contour;

P – Probability value; mm – Millimeter

Table 2 outlines comparative findings for hard-tissue metrics (CBH and RW) in both groups. For Group 1, no meaningful differences were observed in mesial or distal CBH. Similarly, RW values remained relatively consistent throughout follow-up, with P = 0.067 at 2 mm and P = 0.148 at 4 mm from the crest. In contrast, Group 2 exhibited a pronounced alteration in mesial CBH (P = 0.000), although RW changes were not statistically relevant (P = 0.452).

Table 2. Intragroup analysis of hard-tissue characteristics at multiple time points in Group 1 and Group 2

Within-Cohort Analysis of Bone Parameters in Cohort 1	**Baseline**	**3 Months**	**6 Months**	**9 Months**	**12 Months**	**F-Value**	**P-Value**
Mesial Bone Height (mm)	0.89±0.89	1.13±0.59	0.90±0.78	1.93±3.42	1.93±3.42	0.622	0.649

Distal Bone Height (mm)	0.83±0.85	0.80±0.68	0.73±0.78	0.63±0.71	0.63±0.71	0.170	0.953
Ridge Width at 2 mm from Crest (mm)	7.00±0.74	6.21±0.72	6.27±0.74	6.24±0.71	6.24±0.72	2.343	0.067
Ridge Width at 4 mm from Crest (mm)	9.27±0.97	8.69±0.78	8.73±0.71	8.62±0.65	8.46±0.62	1.778	0.148
Within-Cohort Analysis of Bone Parameters in Cohort 2	Baseline	3 Months	6 Months	9 Months	12 Months	F-Value	P-Value
Mesial Bone Height (mm)	0.00±0.00	0.23±0.12	0.31±0.10	0.40±0.07	0.40±0.12	34.358	0.000**
Distal Bone Height (mm)	0.00±0.00	0.14±0.15	0.20±0.13	0.27±0.14	0.61±1.13	2.158	0.087
Ridge Width at 2 mm from Crest (mm)	6.54±0.49	6.16±0.53	6.10±0.56	6.08±0.53	5.87±0.43	2.496	0.054
Ridge Width at 4 mm from Crest (mm)	9.06±0.71	8.94±0.66	8.80±0.62	8.80±0.62	8.55±0.62	0.934	0.452

Highly significant (p<0.001); Significant difference (p<0.05).

BBT – Buccal bone thickness; CBH – Crestal bone height; RW – Ridge width; P – Probability value; F – ANOVA test statistic; mm – Millimeter

Tables 3 and **4** display within-group comparisons from baseline to the 12-month review for both groups. Both analyses revealed significant and highly significant improvements in PI, GI, mSBI, PD, TS, and RW (P < 0.05).

Table 3. Intragroup comparison in Group I between baseline and 12 months

Measurement	Baseline	12 Months	t	P
Plaque Index (PI)	1.45±0.52	0.14±0.50	0.830	0.000**
Gingival Index (GI)	1.7±0.25	1.31±0.24	0.713	0.000**
Modified Sulcular Bleeding Index (mSBI)	1.0±0.71	0.85±0.74	2.563	0.000**
Probing Depth (PD, mm)	2.78±0.50	2.45±0.5	−15.588	0.000**
Tooth Staining (TS)				
TS (a)	0.00±0.00	1.09±0.83	−4.353	0.000**
TS (b)	1.55±0.52	1.55±0.52	0.000	1.000
TS (c)	1.55±0.52	1.55±0.52	0.000	1.000
TS (d)	0.55±0.52	1.55±0.52	−4.491	0.000**
Total TS	0.90±0.16	1.43±0.38	−4.092	0.001*
Buccal Bone Thickness (BBT, mm)				
At Crest	1.67±0.55	1.47±0.48	0.901	0.378
2 mm from Crest	1.58±0.35	1.60±0.30	−0.136	0.893
Mid-implant Level	1.72±0.58	1.79±0.39	−0.301	0.767
Apical Level	2.10±0.78	2.36±0.59	−0.853	0.404
Crestal Bone Height (CBH, mm)				
Mesial	0.89±0.89	1.93±3.42	−0.981	0.338
Distal	0.83±0.85	0.63±0.71	0.594	0.559
Ridge Width (RW, mm)				
2 mm from Crest	7.00±0.74	6.24±0.72	2.403	0.026*
4 mm from Crest	9.27±0.97	8.46±0.62	2.316	0.031*

*Significant (p<0.05); **Highly significant (p<0.001).*

PI – Plaque index; GI – Gingival index; mSBI – Modified sulcus bleeding index; PD – Probing depth; TS – Testori score;
TS (a) – Papilla stability; TS (b) – Peri-implant soft-tissue texture; TS (c) – Peri-implant tissue color;
TS (d) – Gingival contour; BBT – Buccal bone thickness; CBH – Crestal bone height; RW – Ridge width;
P – Probability value; t – Test statistic; mm – Millimeter

Table 4. Intragroup comparison in Group II between baseline and 12 months

Measurement	Baseline	12 Months	t	P
Plaque Index (PI)	1.08±0.00	0.55±0.52	−3.464	0.002**
Gingival Index (GI)	1.7±0.25	1.31±0.24	2.341	0.001**
Modified Sulcular Bleeding Index (mSBI)	1.0±0.71	0.85±0.74	1.765	0.000**
Probing Depth (PD, mm) Testori Score	0.00±0.00	2.18±0.60	−12.000	0.000**
Tooth Staining (TS)				
TS (a)	0.00±0.00	1.36±0.50	−8.964	0.000**
TS (b)	1.45±0.52	1.64±5.0	−0.830	0.416
TS (c)	1.73±0.46	1.82±0.405	−0.488	0.631
TS (d)	0.00±0.00	1.45±0.52	−9.238	0.000**
Total TS	0.79±0.15	1.56±0.29	−7.680	0.000**

Buccal Bone Thickness (BBT)				
At Crest (mm)	1.02±0.32	1.76±0.24	−5.981	0.000**
2 mm from Crest (mm)	1.77±0.46	1.91±0.38	−0.800	0.433
Mid-implant Level (mm)	2.37±0.47	2.44±0.49	−0.351	0.729
Apical Level (mm)	3.31±0.50	3.22±0.39	0.470	0.644
Crestal Bone Height (CBH, mm)				
Mesial	0.00±0.00	0.40±0.12	−11.112	0.000**
Distal	0.00±0.00	0.61±1.13	−1.807	0.086
Ridge Width (RW)				
2 mm from Crest (mm)	6.54±0.49	5.87±0.43	3.368	0.003*
4 mm from Crest (mm)	9.06±0.71	8.55±0.62	1.784	0.090

*Significant ($p<0.05$); **Highly significant ($p<0.001$).*

PI – Plaque index; GI – Gingival index; mSBI – Modified sulcus bleeding index; PD – Probing depth; TS – Testori score;
TS (a) – Papilla stability; TS (b) – Peri-implant tissue texture; TS (c) – Tissue color; TS (d) – Gingival contour;
BBT – Buccal bone thickness; CBH – Crestal bone height; RW – Ridge width; P – Probability value;
t – Test statistic; mm – Millimeter

Discussion

The goal of this clinical investigation was to evaluate alterations in both hard and soft tissues surrounding immediate and delayed implants placed using a flapless surgical technique in the posterior region. In implantology, the health and preservation of peri-implant tissues play a decisive role in determining implant survival rates. Maintaining the integrity of these tissues, along with ensuring proper occlusal balance, greatly contributes to long-term stability. The flapless method used in this study involved removing a minimal circular portion of mucosa to create access for osteotomy preparation. Earlier research has indicated that this approach limits crestal bone reduction and preserves the interproximal papillae [9–11]. A unique aspect of the current research is its specific evaluation of the individual Testori parameters that measure distinct soft-tissue characteristics, along with the composite TS score for overall assessment.

In the present study, PI, GI, and mSBI demonstrated a significant decline over time in both groups. This downward trend is consistent with the observations of DeAngelo *et al.* [12] and Joly *et al.* [13], likely due to improved plaque management achieved through consistent reinforcement of oral hygiene instructions at each recall visit.

The findings revealed a notable improvement in the peri-implant soft-tissue profile, including papillary fill and gingival contour, in both groups after 12 months. However, papillary fill was more prominent in the immediate implant group, possibly related to greater preservation of CBH in these cases. The texture and color of peri-implant tissues showed no significant variation, suggesting that the timing of implant placement—immediate or delayed—has little influence on tissue quality. In contrast, changes in gingival contour were statistically significant, particularly in Group 2, indicating more favorable esthetic outcomes in immediate placements, while delayed cases often displayed flatter gingival margins with reduced scalloping. Additionally, BBT demonstrated more pronounced alterations in delayed implant cases than in immediate ones.

Healing outcomes indicated that Group 1 exhibited superior preservation of crestal bone, which maintained the gingival framework and improved the overall esthetic profile. Immediate implants also offered benefits such as reduced treatment duration, enhanced patient comfort, and maintenance of naturally contoured gingiva.

To ensure successful osseointegration in rapid implant placement, critical parameters such as correct patient selection, minimally traumatic extraction, prophylactic antibiotic coverage, and achieving primary stability are essential [14]. In delayed implant cases, approximately 50% reduction in RW within 12 months is often observed, with nearly two-thirds of remodeling occurring within the initial three months of healing. Lekovic *et al.* [15] reported an average 3–4 mm vertical bone loss, accounting for half the initial socket height at six months post-extraction. Consequently, implant placement in fully healed ridges is generally discouraged, as it often requires additional grafting procedures. Nonetheless, delayed placement remains a feasible alternative in situations involving acute infections or insufficient soft tissue, as it may help stabilize soft-tissue height and limit further ridge resorption [16]. The predictability of immediate versus delayed implant success depends on several factors, including socket morphology, bone quality, implant position, and augmentation requirements.

Both groups in this study demonstrated favorable healing, with no significant clinical discrepancies. These outcomes support recent literature indicating that the overall recovery process for immediate and delayed implants is comparable in both clinical and radiographic terms.

Although Group 2 exhibited slightly narrower RW at baseline, the trend of coronal remodeling (buccolingual narrowing) followed a similar course in both groups. This finding suggests that remodeling begins soon after extraction and continues, though at differing rates, even in delayed placements. Changes in CBH and RW for Group 2 were analogous to those observed in Group 1, aligning with the outcomes reported by Covani *et al.* [17]. As horizontal bone formation dominates over vertical regeneration in post-extraction sockets, vertical assessment was intentionally excluded from this analysis.

In this study, BBT around Group 1 implants showed minimal alteration, indicating stable bone thickness at the time of final restoration—a favorable result for long-term predictability [18]. Should extended follow-up studies validate this trend, it would imply minimal risk of resorption-related complications in the future. Conversely, Group 2 demonstrated a statistically significant change in BBT after 12 months. Initial buccal bone thickness adjacent to implants may influence both vertical and horizontal resorptive changes; however, a definitive threshold value ensuring stability could not be established. No significant difference in BBT between the two groups after 12 months was observed, corresponding with findings by Chochlidakis *et al.* [19]. Similarly, Arora and Ivanovski [20] found no direct relationship between preoperative buccal cortical bone width and the esthetic or soft-tissue outcomes following immediate implant placement and restoration in the maxillary esthetic zone. In a related study, Rathi *et al.* [21] evaluated marginal bone variations around implants with fixed and replaced abutments in 20 subjects and found minor but statistically insignificant bone loss between baseline and 3 months for both groups.

The current findings reinforce prior evidence suggesting that bone remodeling invariably follows implant placement, leading to measurable changes in both vertical and horizontal peri-implant dimensions. Such remodeling is generally more evident in immediate implant cases due to intensified osteoclastic activity following extraction, which enhances bone resorption around the implant interface.

Despite positive outcomes, the present research faced certain limitations, including a restricted sample size and relatively short observation period. Future investigations with larger cohorts and extended follow-up durations are necessary to further validate these outcomes and evaluate the effects of variables such as abutment design, implant geometry, and connection type on peri-implant tissue behavior.

Conclusion

Within the constraints of this clinical trial, it can be inferred that both immediate and delayed implant protocols resulted in significant enhancement of gingival contour and papillary fill after a 12-month period. However, Group 1 achieved superior improvement in soft-tissue esthetics and health compared to Group 2. Variations in BBT and CBH after one year were not statistically significant between the two protocols, while RW showed notable alteration in both groups over the same duration.

Acknowledgments: None

Conflict of interest: None

Financial support: None

Ethics statement: None

References

1. Novaes AB Jr, Suaid F, Queiroz AC, Muglia VA, Souza SL, Palioto DB, et al. Buccal bone plate remodeling after immediate implant placement with and without synthetic bone grafting and flapless surgery: Radiographic study in dogs. J Oral Implantol. 2012;38(6):687-98.

2. Kim JI, Choi BH, Li J, Xuan F, Jeong SM. Blood vessels of the peri-implant mucosa: A comparison between flap and flapless procedures. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107(4):508-12.
3. You TM, Choi BH, Li J, Xuan F, Jeong SM, Jang SO. Morphogenesis of the peri-implant mucosa: A comparison between flap and flapless procedures in the canine mandible. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107(1):66-70.
4. Edward J, George JM, Prakash DG. Evaluation of peri-implant soft and hard tissues in titanium implants in immediate and delayed cases: A comparative study. J Dent Implant. 2017;7(1):3-10.
5. Silness J, Löe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. Acta Odontol Scand. 1964;22(1):121-35.
6. Löe H. The gingival index, the plaque index and the retention index systems. J Periodontol. 1967;38(6):610-6.
7. Mombelli A, van Oosten MA, Schürch E Jr, Land NP. The microbiota associated with successful or failing osseointegrated titanium implants. Oral Microbiol Immunol. 1987;2(4):145-51.
8. Testori T, Bianchi F, Del Fabbro M, Capelli M, Zuffetti F, Berlucchi I, et al. Implant aesthetic score for evaluating the outcome: Immediate loading in the aesthetic zone. Pract Proced Aesthet Dent. 2005;17(2):123-30.
9. Divakar TK, Gidean Arularasan S, Baskaran M, Packiaraj I, Dhineksh Kumar N. Clinical evaluation of implant placement by flapless technique versus conventional flap technique. J Maxillofac Oral Surg. 2020;19(1):74-84.
10. Lahoti K, Dandekar S, Gade J, Agrawal M. Comparative evaluation of crestal bone level by flapless and flap techniques for implant placement: A systematic review and meta-analysis. J Indian Prosthodont Soc. 2021;21(4):328-38.
11. Sunitha RV, Sapthagiri E. Flapless implant surgery: A 2-year follow-up study of 40 implants. Oral Surg Oral Med Oral Pathol Oral Radiol. 2013;116(5):e237-43.
12. DeAngelo SJ, Kumar PS, Beck FM, Tatakis DN, Leblebicioglu B. Early soft tissue healing around one-stage dental implants: Clinical and microbiologic parameters. J Periodontol. 2007;78(11):1878-86.
13. Joly JC, de Lima AF, da Silva RC. Clinical and radiographic evaluation of soft and hard tissue changes around implants: A pilot study. J Periodontol. 2003;74(8):1097-103.
14. Narad C, Lingraj JB, Aulakh KK, Handa K, Kotrashetti SM, Pinto PX. Assessment of primary stability of implants placed in prepared infected extraction sockets. J Oral Biol Craniofac Res. 2018;8(2):154-7.
15. Lekovic V, Kenney EB, Weinlaender M, Han T, Klokkevold P, Nedic M, et al. A bone regenerative approach to alveolar ridge maintenance following tooth extraction: Report of 10 cases. J Periodontol. 1997;68(6):563-70.
16. Schwartz-Arad D, Chaushu G. Immediate implant placement: A procedure without incisions. J Periodontol. 1998;69(6):743-50.
17. Covani U, Cornelini R, Barone A. Vertical crestal bone changes around implants placed into fresh extraction sockets. J Periodontol. 2007;78(5):810-5.
18. Slagter KW, Raghoebar GM, Bakker NA, Vissink A, Meijer HJ. Buccal bone thickness at dental implants in the aesthetic zone: A 1-year follow-up cone beam computed tomography study. J Craniomaxillofac Surg. 2017; 45(1):13-9. doi: 10.1016/j.jcms.2016.11.004
19. Chochlidakis KM, Geminiani A, Papaspyridakos P, Singh N, Ercoli C, Chen CJ. Buccal bone thickness around single dental implants in the maxillary esthetic zone. Quintessence Int. 2017;48(4):295-308.
20. Arora H, Ivanovski S. Correlation between preoperative buccal bone thickness and soft tissue changes around immediately placed and restored implants in the maxillary anterior region: A 2-year prospective study. Clin Oral Implants Res. 2017;28(10):1188-94.
21. Rathi PR, Kolte RA, Kolte AP. Comparative evaluation of peri-implant tissues in definitive and repeated abutment replacements: A randomized clinical trial. J Indian Soc Periodontol. 2022;26(1):44-50.