International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Comparative Evaluation of Marginal Bone Loss and Soft Tissue Thickness in Posterior Implants Placed Using Single Stage and Two Stage Protocols: A Clinical Study

Dr. Vidhi Ahuja[1], Dr. Rajesh Kumar[2], Dr. Sunil Kumar MV[3]

[1]Postgraduate Student, Department of Prosthodontics, Crown and Bridge, Jaipur Dental College,Maharaj Vinayak Global University, Jaipur, Rajasthan, India
[2]Head of Department, Professor, Department of Prosthodontics, Crown and Bridge, Jaipur Dental College,Maharaj Vinayak Global University, Jaipur, Rajasthan, India
[3]Professor, Department of Prosthodontics, Crown and Bridge, Jaipur Dental College, Maharaj Vinayak Global University, Jaipur, Rajasthan, India

Abstract

Background: Dental implants are a predictable treatment modality for the rehabilitation of partially edentulous patients. Long-term success is influenced by peri-implant hard and soft tissue stability, particularly marginal bone levels and soft tissue thickness. The choice of surgical protocol—single-stage (non-submerged) or two-stage (submerged)—may affect peri-implant tissue response, although existing literature presents conflicting evidence.

Aim: To evaluate and compare marginal bone loss and peri-implant soft tissue thickness between single-stage and two-stage implant placement protocols in the mandibular posterior region.

Materials and Methods: This prospective, randomized controlled clinical and radiographic study included 30 partially edentulous patients requiring implant-supported rehabilitation in the mandibular posterior region. Participants were randomly divided into two groups:

- Group A: Single-stage implant placement
- Group B: Two-stage implant placement

Marginal bone levels were assessed using standardized intraoral periapical radiographs at baseline (T0), 3 months (T1), and 6 months (T2). Peri-implant soft tissue thickness was measured using the transgingival probing method at corresponding time intervals. Intragroup and intergroup comparisons were performed using appropriate statistical analysis.

Results: Both groups demonstrated acceptable marginal bone remodeling and soft tissue healing over the study period. However, the single-stage implant placement protocol showed comparatively lesser marginal bone loss and slightly greater peri-implant soft tissue thickness than the two-stage protocol. The differences were found to be clinically favorable toward the single-stage approach.

Conclusion: Both single-stage and two-stage implant placement protocols are clinically reliable for implant rehabilitation. However, the single-stage protocol may offer advantages in terms of reduced marginal bone loss, improved peri-implant soft tissue thickness, decreased treatment time, and elimination of a second surgical procedure. Further long-term studies are recommended to substantiate these findings.

Keywords: Dental implants; single-stage implant placement; two-stage implant placement; marginal bone loss; peri-implant soft tissue thickness; mandibular posterior region; peri-implant tissue stability.

1. INTRODUCTION

Dental implants have become a predictable and widely accepted treatment modality for the rehabilitation of partially and completely edentulous patients. The biological basis for their long-term success is osseointegration, which provides a stable foundation for functional loading and prosthetic rehabilitation. However, successful osseointegration alone does not determine the long-term clinical outcome of an implant. The maintenance of peri-implant hard and soft tissue stability is equally important for preserving implant function, biological health, and prosthetic success.

Marginal bone stability is considered one of the important parameters for evaluating peri-implant health. A certain degree of crestal bone remodeling is expected following implant placement and establishment of the peri-implant biological width. However, excessive or progressive marginal bone loss may compromise peri-implant tissue health, implant stability, and the prosthetic prognosis. Alongside hard tissue changes, the peri-implant soft tissue plays an important role in establishing and maintaining a stable biological seal around the implant. In particular, soft tissue thickness has been associated with peri-implant bone stability, biological width formation, and favorable soft tissue outcomes.

The surgical protocol used for implant placement is one of the factors that may influence the healing and subsequent behavior of peri-implant tissues. The two-stage or submerged protocol involves placement of the implant below the mucosa during the initial surgical procedure, followed by a second surgical intervention for implant exposure and healing abutment placement. This approach was historically developed to protect the bone–implant interface during the initial healing period. In contrast, the single-stage or non-submerged protocol permits transmucosal healing, with the healing abutment connected at the time of implant placement, thereby eliminating the need for a second surgical procedure.

Although both protocols have demonstrated predictable osseointegration and favorable implant survival, their effects on peri-implant hard and soft tissue response remain debated. Previous comparative studies have reported similar clinical outcomes and marginal bone responses between submerged and non-submerged approaches, while some evidence suggests potential advantages of the single-stage protocol, including reduced surgical intervention, treatment time, and patient morbidity. The differences in study design, sample size, follow-up duration, assessment methods, and clinical parameters have contributed to variability in the reported findings.

The relationship between peri-implant soft tissue thickness and marginal bone stability provides an additional biological consideration when comparing these protocols. Thicker peri-implant mucosa may provide greater tissue dimension for establishment of the peri-implant biological width, potentially reducing the need for compensatory crestal bone remodeling. Conversely, disruption of the peri-implant soft tissue seal during secondary surgical procedures or repeated manipulation of the implant–abutment interface may influence peri-implant tissue stability.

The posterior mandibular region represents a clinically relevant site for evaluating these changes because of its functional loading conditions and distinct anatomical and biomechanical characteristics. Despite extensive research on implant placement protocols, the available evidence remains inconsistent, and there is a relative lack of prospective clinical and radiographic studies evaluating both hard and soft tissue parameters simultaneously in this region.

Therefore, the present prospective randomized controlled clinical and radiographic study was undertaken to evaluate and compare marginal bone loss and peri-implant soft tissue thickness associated with single-stage and two-stage implant placement protocols in the mandibular posterior region. By assessing both hard and soft tissue parameters at defined intervals during the early healing and functional phases, the study aimed to provide a more comprehensive understanding of the influence of implant placement protocol on peri-implant tissue stability.

2. Materials and Methods

2.1 Study Design and Setting

The present study was designed as a prospective, randomized controlled clinical and radiographic study. It was conducted in the Department of Prosthodontics, Crown & Bridge and Implantology, Jaipur Dental College and Hospital, Maharaj Vinayak Global University, Jaipur. The study protocol was reviewed and approved by the Institutional Ethics Committee of Jaipur Dental College and Hospital. Written informed consent was obtained from all participants before inclusion in the study.

2.2 Study Population

A total of 30 partially edentulous patients with missing teeth in the mandibular posterior region and requiring implant-supported prosthetic rehabilitation were recruited. Participants were randomly allocated into two equal groups of 15 each.

2.3 Eligibility Criteria

Patients requiring implant-supported rehabilitation in the mandibular posterior region, including single-tooth or short-span edentulous spaces, with adequate bone support and healed edentulous sites suitable for implant placement were included. Systemically healthy individuals who were willing to participate and provide informed consent were considered eligible. Patients with poor oral hygiene, uncontrolled systemic disease, active periodontal disease, severe bruxism or parafunctional habits, or cases requiring extensive bone grafting before implant placement were excluded.

2.4 Group Allocation and Surgical Protocol

Group A consisted of 15 patients treated with a single-stage non-submerged implant placement protocol. The implant was placed with a healing abutment protruding through the mucosa, permitting transmucosal healing and eliminating the need for a second surgical exposure. Group B consisted of 15 patients treated with a two-stage submerged implant placement protocol. The implant was completely covered by mucosa during the initial surgery and subsequently exposed during a second-stage procedure for placement of the healing abutment.

The Dentis Implant System SQ Fixture System and corresponding surgical components were used for implant placement. Surgical procedures were performed using standard aseptic protocols and local anesthesia. Following satisfactory healing and clinical evaluation, prosthetic rehabilitation was initiated according to the clinical requirements of each case.

2.5 Clinical and Radiographic Evaluation

Clinical and radiographic evaluations were performed at standardized intervals: T0, immediately after implant placement; T1, 3 months after implant placement; and T2, 6 months after implant placement. The selected intervals permitted evaluation of early healing and subsequent tissue adaptation following prosthetic rehabilitation.

2.6 Assessment of Marginal Bone Loss

Standardized intraoral periapical radiographs were obtained using the paralleling technique. Marginal bone levels were assessed from a fixed reference point on the implant platform to the most coronal bone-to-implant contact on the mesial and distal surfaces. Measurements were recorded in millimeters using radiographic calibration to minimize magnification-related error. Marginal bone loss was calculated from changes in bone levels between the evaluated time points. Mesial and distal measurements were analyzed separately, and an overall average was obtained from the two surfaces.

2.7 Assessment of Peri-Implant Soft Tissue Thickness

Peri-implant soft tissue thickness was evaluated using a transgingival probing technique. Following topical anesthesia, a sterile periodontal probe or endodontic file with a rubber stopper was inserted perpendicular to the peri-implant mucosa until bone contact was reached. The stopper was adjusted to the mucosal surface, after which the instrument was withdrawn and the measurement was recorded in millimeters. The measurement was obtained at the buccal aspect of the implant site using a standardized approach.

2.8 Statistical Analysis

The collected data were summarized using descriptive statistics. Mesial and distal marginal bone measurements were analyzed separately, and both intragroup and intergroup comparisons were performed for marginal bone loss and peri-implant soft tissue thickness. Statistical significance was considered at $p < 0.05$. The statistical procedures reported in the thesis were used without introducing additional analyses not documented in the source study.

3. Results

Thirty participants completed the study, with 15 participants in each group. Group A represented the single-stage protocol and Group B represented the two-stage protocol. Marginal bone loss increased progressively over time in both groups; however, the magnitude of loss was consistently greater in the two-stage group.

3.1 Marginal Bone Loss

At the mesial aspect, the mean bone loss from T0 to T1 was 0.287 ± 0.064 mm in Group A and 0.487 ± 0.064 mm in Group B. From T0 to T2, mean mesial bone loss increased to 0.547 ± 0.092 mm in Group A and 0.940 ± 0.051 mm in Group B. During T1 to T2, the corresponding values were 0.260 ± 0.074 mm and 0.453 ± 0.052 mm. All intergroup differences were statistically significant ($p = 0.001$).

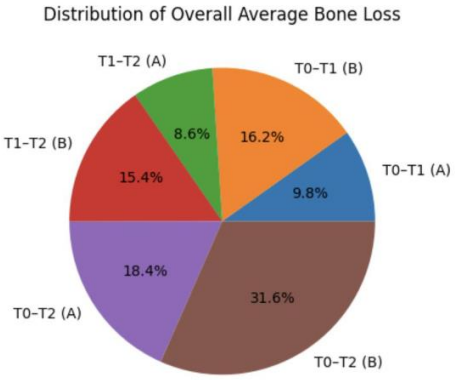
At the distal aspect, the mean bone loss from T0 to T1 was 0.320 ± 0.086 mm in Group A and 0.520 ± 0.086 mm in Group B. From T0 to T2, the values were 0.593 ± 0.088 mm and 1.020 ± 0.086 mm, respectively. During T1 to T2, the corresponding values were 0.273 ± 0.070 mm and 0.500 ± 0.038 mm. These intergroup differences were also statistically significant ($p = 0.001$).

Comparison	Group	N	Mean Bone Loss (mm)	SD	SE	p-value	Significance
T0–T1	Group A	15	0.304	0.075	0.020	0.001	Significant
	Group B	15	0.504	0.075	0.020		
T0–T2	Group A	15	0.570	0.090	0.024	0.001	Significant
	Group B	15	0.980	0.069	0.018		
T1–T2	Group A	15	0.267	0.072	0.019	0.001	Significant
	Group B	15	0.477	0.045	0.012		

Table 1: Overall Average Marginal Bone Loss Between Groups

The overall average marginal bone loss, calculated from mesial and distal measurements, was significantly lower in the single-stage group at every evaluated interval. The largest between-group difference was

observed from T0 to T2, when the mean bone loss was 0.570 mm in Group A compared with 0.980 mm in Group B.



Graph 1: Distribution of overall average marginal bone loss across different time intervals in single-stage and two-stage implant groups.

3.2 Peri-Implant Soft Tissue Thickness

Comparison	Group	N	Mean	Std. Deviation	Std. Error Mean	P value	Significance
Group A	T0	15	1.667	0.244	0.063	0.001	Significant
	T1	15	2.667	0.244	0.063		
	T2	15	3.167	0.244	0.063		
Group B	T0	15	1.633	0.229	0.059	0.001	Significant
	T1	15	2.167	0.244	0.063		
	T2	15	3.167	0.244	0.063		

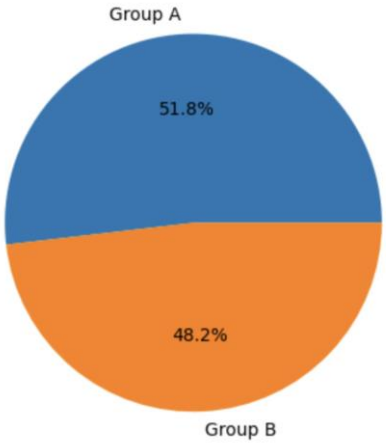
Table 2: Peri-Implant Soft Tissue Thickness at Different Time Points

Soft tissue thickness increased significantly over time in both groups (p = 0.001). Group A increased from 1.667 ± 0.244 mm at T0 to 2.667 ± 0.244 mm at T1 and 3.167 ± 0.244 mm at T2. Group B increased from 1.633 ± 0.229 mm at T0 to 2.167 ± 0.244 mm at T1 and 3.167 ± 0.244 mm at T2.

Interval	Single-Stage Change ± SD (mm)	Two-Stage Change ± SD (mm)	p value	Significance
T0–T1	1.000 ± 0.000	0.533 ± 0.297	0.001	Significant
T0–T2	1.500 ± 0.000	1.033 ± 0.297	0.001	Significant
T1–T2	0.500 ± 0.000	0.500 ± 0.000	1.000	Not significant

Table 3: Intergroup Comparison of Change in Peri-Implant Soft Tissue Thickness

The intergroup comparison demonstrated a significantly greater increase in soft tissue thickness in the single-stage group from T0 to T1 and from T0 to T2. However, the increase from T1 to T2 was identical in both groups and was not statistically significant. By 6 months, both groups demonstrated the same mean soft tissue thickness of 3.167 mm.



Graph 2: Distribution of Overall Soft Tissue Thickness Between Group A and Group B

4. Discussion

The present study evaluated two important components of peri-implant tissue stability, namely marginal bone loss and peri-implant soft tissue thickness, following single-stage and two-stage implant placement in the mandibular posterior region. Both protocols demonstrated progressive tissue adaptation over the 6-month observation period; however, the magnitude and pattern of change differed between the groups.

Marginal bone remodeling is a recognized biological response following implant placement and establishment of the peri-implant biological width. The present findings demonstrated progressive bone loss in both groups, but the two-stage group consistently exhibited greater mesial, distal, and overall marginal bone loss. This difference was statistically significant at every evaluated interval.

The greater marginal bone loss observed in the two-stage group may be related to the additional surgical intervention required for implant exposure and healing abutment placement. Secondary manipulation of the peri-implant soft tissues can disturb the established tissue seal and necessitate further tissue remodeling. The implant-abutment microgap and repeated abutment manipulation have also been implicated in inflammatory changes and crestal bone remodeling [8,9].

The present findings are consistent with reports by Becker et al., who demonstrated predictable clinical outcomes with one-stage implants, and with the systematic review by Esposito et al., which supported the clinical reliability of both protocols [10,11]. However, other investigations have reported no significant differences in marginal bone loss or implant success between submerged and non-submerged approaches [12,13]. These differences emphasize that implant success is multifactorial and may be influenced by implant design, surgical technique, primary stability, loading, oral hygiene, and maintenance rather than the surgical protocol alone.

Peri-implant soft tissue thickness showed a significant increase over time in both groups. The single-stage group demonstrated a greater early increase, with a gain of 1.000 mm during the first 3 months compared with 0.533 mm in the two-stage group. The difference remained significant when the total change from baseline to 6 months was considered. This finding may be explained by the continuous transmucosal

healing environment of the single-stage protocol, which permits uninterrupted maturation of the peri-implant mucosa without a second surgical disruption.

By the 6-month evaluation, both groups reached the same mean soft tissue thickness of 3.167 mm. Thus, the advantage observed with the single-stage protocol was primarily an early difference in tissue gain rather than a persistent difference in final mean thickness. This distinction is clinically important and should be considered when interpreting the biological significance of the findings.

The relationship between soft tissue thickness and marginal bone stability provides a possible biological explanation for the findings. Thicker peri-implant mucosa may provide adequate dimensions for establishment of the peri-implant biological width and may reduce the need for compensatory crestal bone remodeling. Previous studies and systematic reviews have reported an association between thin peri-implant mucosa and greater crestal bone changes [14,15].

The posterior mandibular region was selected because it represents a clinically relevant environment with considerable functional loading. Nevertheless, the present study was limited by its relatively small sample size, short 6-month follow-up, and use of two-dimensional intraoral periapical radiographs for assessment of marginal bone changes. Patient-related factors such as oral hygiene, occlusal loading patterns, and biological variability were not extensively analyzed. Soft tissue measurement at the 6-month evaluation also required access to the implant platform, which may introduce minor procedural variability.

Within these limitations, the results suggest that the single-stage approach may provide favorable early peri-implant tissue behavior, particularly with respect to marginal bone preservation and early soft tissue gain. However, the findings should not be interpreted as establishing universal superiority of one protocol. Selection of the surgical approach should remain dependent on primary stability, bone quality and quantity, soft tissue conditions, implant position, loading considerations, and overall clinical circumstances.

5. Conclusion

Within the limitations of this prospective 6-month study, both single-stage and two-stage implant placement protocols demonstrated favorable peri-implant tissue adaptation in the mandibular posterior region. The single-stage protocol showed significantly lower marginal bone loss at mesial, distal, and overall measurements and demonstrated a significantly greater early increase in peri-implant soft tissue thickness. However, both groups reached comparable mean soft tissue thickness by 6 months. The findings suggest that single-stage implant placement may offer biological and procedural advantages in appropriately selected cases with adequate primary stability and favorable clinical conditions. Future research involving broader patient populations and extended follow-up is needed to determine the long-term clinical relevance of these early differences.

6. Limitations

- The study included a relatively small sample of 30 participants and was conducted at a single institution.
- The follow-up period was limited to 6 months and therefore did not permit assessment of long-term implant survival or prosthetic complications.
- Marginal bone levels were evaluated using two-dimensional intraoral periapical radiographs, which cannot fully characterize three-dimensional bone changes.

- Patient-related variables such as detailed occlusal loading patterns, oral hygiene behavior, and individual biological variation were not extensively evaluated.
- The 6-month soft tissue assessment required access to the implant platform and may have introduced minor procedural variability.

References

1. Brånemark PI, Adell R, Breine U, Hansson BO, Lindström J, Ohlsson Å. Intra-osseous anchorage of dental prostheses. I. Experimental studies. Scandinavian Journal of Plastic and Reconstructive Surgery. 1969;3(2):81–100.
2. Brånemark PI, Hansson BO, Adell R, Breine U, Lindström J, Hallén O, et al. Osseointegrated implants in the treatment of the edentulous jaw. Scandinavian Journal of Plastic and Reconstructive Surgery Supplement. 1977;16:1–132.
3. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. International Journal of Oral and Maxillofacial Implants. 1986;1(1):11–25.
4. Berglundh T, Lindhe J, Ericsson I, Marinello C, Liljenberg B, Thomsen P. The soft tissue barrier at implants and teeth. Clinical Oral Implants Research. 1991;2(2):81–90.
5. Hermann JS, Cochran DL, Nummikoski PV, Buser D. Crestal bone changes around titanium implants. Journal of Periodontology. 2000;71(9):1412–1424.
6. Hermann JS, Schoolfield JD, Schenk RK, Buser D, Cochran DL. Influence of the size of the microgap on crestal bone changes around titanium implants. Journal of Periodontology. 2001;72(10):1372–1383.
7. Abrahamsson I, Berglundh T, Lindhe J. The mucosal barrier following abutment dis/reconnection: an experimental study in dogs. Journal of Clinical Periodontology. 1998;25(7):568–572.
8. Lang NP, Berglundh T. Peri-implant diseases: where are we now? Consensus of the Seventh European Workshop on Periodontology. Journal of Clinical Periodontology. 2011;38(Suppl 11):178–181.
9. Buser D, Weber HP, Brägger U. The treatment of partially edentulous patients with ITI hollow-screw implants: presurgical evaluation and surgical procedures. International Journal of Oral and Maxillofacial Implants. 1990;5(2):165–173.
10. Becker W, Becker BE, Ricci A, Bahat O, Rosenberg E, Rose LF. A prospective multicenter clinical trial comparing one-stage and two-stage titanium screw-shaped fixtures. Clinical Implant Dentistry and Related Research. 1997;8(3):159–165.
11. Esposito M, Grusovin MG, Willings M, Coulthard P, Worthington HV. Interventions for replacing missing teeth: one-stage versus two-stage implant placement. Cochrane Database of Systematic Reviews. 2010;(3):CD006698.
12. Buser D, Mericske-Stern R, Bernard JP, Behneke A, Behneke N, Hirt HP, et al. Long-term evaluation of non-submerged ITI implants. Clinical Oral Implants Research. 2000;11(6):595–606.
13. Lang NP, Pjetursson BE, Tan K, Brägger U, Egger M, Zwahlen M. A systematic review of the survival and complication rates of fixed partial dentures after an observation period of at least 5 years. Clinical Oral Implants Research. 2004;15(6):625–642.
14. Linkevicius T, Linkevicius R, Alkimavicius J, Linkeviciene L, Andrijauskas P, Puisys A. Influence of soft tissue thickness on crestal bone changes around implants: a systematic review. Journal of Periodontology. 2015;86(5):606–612.

15. Suárez-López Del Amo F, Lin GH, Monje A, Galindo-Moreno P, Wang HL. Influence of soft tissue thickness on peri-implant marginal bone loss: a systematic review and meta-analysis. Journal of Periodontology. 2016;87(6):690–699.
16. Bressan E, et al. Influence of soft tissue thickness on marginal bone level around dental implants: a systematic review with meta-analysis and trial-sequential analysis. Clinical Oral Implants Research. 2023;34(5):405–415.