Quest Journals
Journal of Medical and Dental Science Research
Volume 13~ Issue 4 (April 2026) pp: 56-58
ISSN(Online): 2394-076X ISSN (Print):2394-0751
www.questjournals.org

Research Paper

Comparative Assessment of Marginal Bone Loss Following Immediate and Delayed Implant Placement in the Posterior Mandible: A Prospective Clinical Study of 250 Patients

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Abstract: *Background: Marginal bone preservation is essential for long-term implant success. Immediate implant placement shortens treatment time but may influence early crestal bone remodeling compared with delayed placement.*
Objective: To compare marginal bone loss (MBL) between immediate and delayed implant placement in the posterior mandible over 24 months.
Materials and Methods: A prospective cohort study was conducted on 250 patients requiring single posterior mandibular implants. Patients were allocated into immediate (n=125) and delayed placement groups (n=125). Standardized surgical and prosthetic protocols were followed. Radiographic MBL was measured at baseline, 6, 12, and 24 months. Statistical analysis included repeated-measures ANOVA and independent t-tests ($p<0.05$).
Results: At 24 months, mean MBL was 1.21 ± 0.36 mm in the immediate group and 1.05 ± 0.33 mm in the delayed group ($p=0.004$). Most bone remodeling occurred within the first 6 months. Implant survival rates were 97.6% (immediate) and 98.4% (delayed).
Conclusion: Immediate implant placement in the posterior mandible results in slightly greater marginal bone remodeling than delayed placement; however, both approaches demonstrate high survival rates and clinically acceptable outcomes.

Keywords: *Immediate implant placement, delayed implant placement, marginal bone loss, posterior mandible, dental implants.*

*Received 09 Apr., 2026; **R**evised 24 Apr., 2026; **A**ccepted 25 Apr., 2026 © The author(s) 2026.*
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I. INTRODUCTION

Osseointegrated dental implants are a well-established treatment modality for replacing missing teeth, demonstrating predictable long-term outcomes when appropriate surgical and prosthetic principles are followed [1,2]. Long-term implant success depends not only on osseointegration but also on preservation of crestal bone levels surrounding the implant fixture [1,13].

Historically, implant placement was performed after complete healing of the extraction socket, typically 3–6 months post-extraction, to allow adequate bone maturation [3]. This delayed protocol has been regarded as biologically safe and predictable. However, immediate implant placement—defined as insertion of the implant at the time of tooth extraction—has gained clinical popularity due to reduced treatment time and preservation of alveolar ridge dimensions [4].

Physiologic dimensional changes occur following tooth extraction, including horizontal and vertical bone resorption [7,14]. Immediate placement has been proposed as a strategy to mitigate post-extraction bone loss, although crestal remodeling still occurs [10]. Systematic reviews comparing timing protocols suggest similar survival rates between immediate and delayed implants, though early marginal bone changes may differ [6,9].

The posterior mandible presents distinct biomechanical considerations, including dense cortical bone and higher occlusal loading [5,11]. Bone density influences primary stability and may affect crestal bone adaptation [5]. Marginal bone stability is also influenced by surgical trauma, implant design, loading protocol, and peri-implant inflammation [8,16]. According to widely accepted success criteria, marginal bone loss should not exceed 1.5 mm during the first year of function and 0.2 mm annually thereafter [1]. Given ongoing debate regarding optimal timing in posterior mandibular sites, this study aimed to compare marginal bone loss between immediate and delayed implant placement over a 24-month period.

II. MATERIALS AND METHODS

Study Design

This prospective cohort study was conducted at a university-based implantology center. Ethical approval was obtained, and informed consent was secured from all participants.

Sample Size and Patient Selection

A total of 250 patients aged 25–65 years requiring single-tooth replacement in the posterior mandible (premolar or molar region) were enrolled.

Inclusion Criteria

- Good systemic health
- Adequate bone volume without need for major augmentation
- Absence of active periodontal infection

Exclusion Criteria

- Uncontrolled systemic disease
- Heavy smoking (>10 cigarettes/day)
- History of head and neck radiotherapy

Group Allocation

Patients were assigned into two groups

- Group A (Immediate Placement): 125 implants placed immediately after atraumatic extraction.
- Group B (Delayed Placement): 125 implants placed 3–4 months post-extraction in healed ridges.

All implants were titanium, rough-surfaced, internal-connection systems

Surgical Protocol

All procedures were performed under local anesthesia. Primary stability of ≥35 Ncm was achieved in all cases. In the immediate group, socket debridement was performed and peri-implant gaps greater than 2 mm were grafted, consistent with recommendations for managing jumping distance defects [10]. Healing abutments were placed, and prosthetic loading was performed after 3 months.

Radiographic Assessment

Standardized digital periapical radiographs were obtained using a paralleling technique. Marginal bone levels were measured from the implant platform to the first bone-to-implant contact on mesial and distal surfaces. Measurements were calibrated using implant thread pitch as reference [16].

Evaluations were performed at:

- Baseline (implant placement)
- 6 months
- 12 months
- 24 months

STATISTICAL ANALYSIS

Data were analyzed using SPSS software. Independent t-tests compared intergroup differences at each time interval. Repeated-measures ANOVA evaluated temporal changes within groups. Significance was set at $p < 0.05$.

III. RESULTS

Demographic Data

The mean age of participants was 43.8 ± 8.9 years. Gender distribution and baseline clinical characteristics showed no statistically significant differences between groups.

RESULTS

Marginal Bone Loss

Time Point	Immediate (Mean ± SD)	Delayed (Mean ± SD)	p-value
6 months	0.86 ± 0.28 mm	0.70 ± 0.26 mm	0.002
12 months	1.08 ± 0.34 mm	0.92 ± 0.30 mm	0.003
24 months	1.21 ± 0.36 mm	1.05 ± 0.33 mm	0.004

The majority of bone remodeling occurred during the first 6 months, consistent with physiologic crestal adaptation following surgical intervention [7,10].

Implant Survival

- Immediate group: 122/125 (97.6%)
- Delayed group: 123/125 (98.4%)

No statistically significant difference was observed, aligning with survival rates reported in systematic reviews [6,9].

IV. DISCUSSION

The present study demonstrated slightly greater marginal bone remodeling in immediate implant placement compared with delayed placement in posterior mandibular sites. However, the difference remained within accepted clinical success criteria [1]. Post-extraction bone remodeling is a well-documented phenomenon [7,14]. Although immediate implant placement may reduce horizontal ridge collapse, crestal bone adaptation still occurs due to physiologic healing processes [10]. Bone density in the posterior mandible may contribute to favorable primary stability, which has been associated with improved outcomes [5,11].

The survival rates observed in both groups are consistent with long-term implant data demonstrating high predictability of osseointegrated implants [2,17]. The absence of significant differences in peri-implant clinical parameters suggests stable soft tissue health, which plays an important role in maintaining crestal bone levels [8]. Systematic reviews and meta-analyses have reported comparable long-term outcomes between timing protocols, supporting the findings of this study [6,9]. Therefore, immediate placement, when performed with appropriate case selection and surgical precision, may be considered a reliable alternative to delayed placement.

Limitations

- Non-randomized design
- Two-dimensional radiographic assessment
- Single implant system used
- Follow-up limited to 24 months

Long-term randomized controlled trials incorporating three-dimensional imaging are recommended.

V. CONCLUSION

Immediate implant placement in the posterior mandible resulted in slightly greater marginal bone loss compared with delayed placement over 24 months; however, both protocols demonstrated high survival rates and stable peri-implant conditions. Immediate placement can be considered a predictable and efficient treatment modality when clinical guidelines are followed.

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