



www.bioinformation.net
Volume 22(9)



Research Article

Received September 1, 2026; Revised September 30, 2026; Accepted September 30, 2026, Published September 30, 2026

DOI: 10.6026/973206300225850

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478

2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

Declaration on Publication Ethics:

The author's state that they adhere with COPE guidelines on publishing ethics as described elsewhere at <https://publicationethics.org/>. The authors also undertake that they are not associated with any other third party (governmental or non-governmental agencies) linking with any form of unethical issues connecting to this publication. The authors also declare that they are not withholding any information that is misleading to the publisher in regard to this article.

Declaration on official E-mail:

The corresponding author declares that lifetime official e-mail from their institution is not available for all authors

License statement:

This is an Open Access article which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited. This is distributed under the terms of the Creative Commons Attribution License

Comments from readers:

Articles published in BIOINFORMATION are open for relevant post publication comments and criticisms, which will be published immediately linking to the original article without open access charges. Comments should be concise, coherent and critical in less than 1000 words.

Disclaimer:

Bioinformation provides a platform for scholarly communication of data and information to create knowledge in the Biological/Biomedical domain after adequate peer/editorial reviews and editing entertaining revisions where required. The views and opinions expressed are those of the author(s) and do not reflect the views or opinions of Bioinformation and (or) its publisher Biomedical Informatics. Biomedical Informatics remains neutral and allows authors to specify their address and affiliation details including territory where required.

Edited by Ruby Singh

E-mail: bioinformationruby@gmail.com

Citation: Giri *et al.* Bioinformation 22(9): 5850-5853 (2026)

Immediate versus delayed implant placement in single-tooth sites: A randomized controlled trial

Rishabh Giri¹, Vertika Dubey^{2,*}, Yashvi Bindeshkumar Patel³, Farheen Chunara⁴, Sameer Gupta⁵ & Sapna Pandey⁶

¹Department of Dentistry, Chirayu Medical College, Bairagarh, Bhopal, Madhya Pradesh, India; ²Department of Dentistry, Birs Munda Government Medical College, Shahdol, Madhya Pradesh, India; ³Department of Dentistry, K.H. Patel Dental Home, Ahmedabad, Gujarat, India; ⁴Department of Biostatistics, Data Science Institute, Medical College of Wisconsin, Milwaukee, Wisconsin, USA; ⁵Department of Oral & Maxillofacial Surgery, Inderprastha Dental College and Hospital, Sahibabad, Ghaziabad, Uttar Pradesh, India; ⁶Department of Oral and Maxillofacial Surgery, Chandra Dental College and Hospital, Dharsania, Barabanki district, Uttar Pradesh, India; *Corresponding author

Affiliation URL:

<https://cmchbhopal.com/>

<https://gmcsahdol.org/>
<http://khp dentalhome.com/>
<https://www.mcw.edu/>
<https://www.ipdentalcollege.com/>
<https://chandradentalcollege.org/>

Author contact:

Rishabh Giri - E-mail: giririshabh@gmail.com
Vertika Dubey - E-mail: vertikad19@gmail.com
Yashvi Bindeshkumar Patel - E-mail: yashvi_150289@yahoo.com
Farheen Chunara - E-mail: farheenchunara@gmail.com
Sameer Gupta - E-mail: sameer.gupta83@yahoo.in
Sapna Pandey - E-mail: sapnaakp@gmail.com

Abstract:

The ideal timing of implant placement after tooth extraction remains debated due to differences in clinical and esthetic outcomes. Therefore, it is of interest to compare the immediate (n = 50) and delayed (n = 50) implant placement in 100 patients over 12 months. Delayed placement showed significantly greater implant stability, less marginal bone loss and better esthetic outcomes (all $p < 0.01$). Both protocols achieved high implant survival, while immediate placement promoted faster soft-tissue healing. Thus, data support evidence-based selection of implant timing according to clinical and esthetic treatment goals.

Keywords: Dental implant, immediate implant placement, delayed implant placement, implant stability quotient, marginal bone loss, pink esthetic score and randomized controlled trial

Background:

Replacement of a single tooth with an endosseous implant can be timed as immediate (Type 1), early with soft-tissue healing (Type 2), early with partial bone healing (Type 3), or delayed after complete socket healing (Type 4) [1]. Immediate implant placement shortens treatment duration and reduces the number of surgical procedures, while systematic reviews have showed survival rates comparable to delayed placement [2]. However, implants placed into fresh extraction sockets generally exhibit lower primary stability and greater peri-implant bone remodeling than those inserted into healed sites, potentially affecting marginal bone levels and esthetic outcomes [3]. Patient-related factors, particularly smoking and baseline socket conditions, further influence implant success and early failure risk regardless of placement timing [4, 5]. Despite extensive evidence, few randomized trials have comprehensively evaluated implant stability, marginal bone loss, soft-tissue esthetics, patient satisfaction, complications and survival within the same cohort [6]. Therefore, it is of interest to compare the outcomes between immediate and delayed single-tooth implant placement over a 12-month follow-up period.

Materials and Methods:

This randomized controlled trial was conducted in the Chirayu Medical College, Bargarh, Bhopal, Madhya Pradesh, India, after institutional ethics committee approval and written informed consent from all participants. Adult patients requiring single-tooth extraction and replacement in the anterior (incisor/canine) or premolar region, with adequate residual bone volume (Lekholm & Zarb bone quality D1–D4) to permit primary implant stability, were consecutively screened. Indications for extraction included failed endodontic treatment,

vertical root fracture and other non-restorable carious or periodontally compromised teeth. Patients with acute periapical infection precluding immediate placement, insufficient buccal bone for primary implant stability, uncontrolled systemic disease, heavy smoking beyond the recorded categorical status, or need for extensive bone or soft-tissue grafting were excluded. One hundred eligible participants were randomized in a 1:1 ratio, using a computer-generated randomization sequence with allocation concealment, to immediate implant placement (implant placed at the time of extraction, n = 50) or delayed implant placement (implant placed after approximately 12 weeks of unassisted socket healing, n = 50). Site- and patient-level baseline variables were recorded for all participants, including age, sex, smoking status, tooth site (FDI notation) and region, reason for extraction; Lekholm & Zarb bone quality, gingival biotype and buccal bone plate thickness measured at the time of implant placement. Implant length and diameter were selected by the treating clinician according to residual bone volume and were recorded for each patient. All implants were placed by experienced implantologists using a standardized surgical protocol; immediately placed implants were positioned palatal/lingual to the extraction socket with the residual gap left to heal without mandatory grafting and delayed implants were placed into a fully healed ridge. All participants were followed for 12 months. The primary outcome was implant survival at 12 months. Primary and secondary implant stability was measured by resonance frequency analysis (Ostell, ISQ units, 0–100) at the time of placement and again at 3 and 6 months. Radiographic marginal bone loss (mesial-distal average, standardized periapical radiographs) was recorded at 6 and 12 months. Peri-implant soft-tissue esthetics was assessed at 12 months using the Pink Esthetic Score (0–14 scale). Patient-reported satisfaction was

recorded on a 0–10 Visual Analogue Scale and the time to complete soft-tissue healing/final restoration was recorded in weeks. Complications (e.g., wound infection, peri-implant mucositis, soft-tissue dehiscence, early implant failure) were documented for all participants. Continuous data are expressed as mean ± standard deviation. Normality was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests; data followed a parametric (normal) distribution. Between-group comparisons of continuous variables were performed using the independent-samples t-test (Welch correction for unequal variances where indicated). Categorical variables were compared using the chi-square test, with Fisher's exact test substituted where expected cell counts were below 5. The significance level was set at $p \leq 0.05$. All analyses were performed with IBM® SPSS® Statistics.

Results:

Of the 100 patients randomized, all completed the 12-month follow-up and were available for analysis (50 immediate, 50 delayed). Baseline demographic and site characteristics were well balanced between groups, with no significant between-group differences in age, sex distribution, smoking status, tooth region, bone quality, gingival biotype, buccal bone thickness, or selected implant dimensions (Table 1). As expected from the fresh-socket surgical environment, primary stability at implant placement was significantly lower in the immediate group than the delayed group (ISQ 68.50 ± 4.95 vs 72.86 ± 5.33 , $p < 0.001$).

Comparison of 12-month outcomes is presented in (Table 2). Secondary implant stability remained significantly lower in the immediate group at both 3 months (72.92 ± 6.14 vs 79.88 ± 5.93 , $p < 0.001$) and 6 months (77.54 ± 6.66 vs 83.42 ± 5.85 , $p < 0.001$). Radiographic marginal bone loss was significantly greater with immediate placement at both 6 months (0.53 ± 0.24 mm vs 0.35 ± 0.20 mm, $p < 0.001$) and 12 months (0.83 ± 0.31 mm vs 0.63 ± 0.25 mm, $p < 0.001$). The Pink Esthetic Score at 12 months was modestly but significantly lower with immediate placement (10.48 ± 1.50 vs 11.34 ± 1.24 , $p = 0.002$). Patient-reported satisfaction on the VAS did not differ significantly between groups (8.34 ± 1.02 vs 8.60 ± 0.81 , $p = 0.162$). Soft-tissue healing time was markedly and significantly shorter with immediate placement (14.02 ± 2.27 weeks vs 21.78 ± 3.21 weeks, $p < 0.001$), reflecting the additional pre-implant healing interval built into the delayed protocol. Implant survival at 12 months was high in both groups and did not differ significantly (49/50, 98.0% immediate vs 48/50, 96.0% delayed; $p = 1.000$, Fisher's exact test). Complications were infrequent in both groups; wound infection and peri-implant microsites were each recorded in 6 immediate-group patients versus 2 and 1 delayed-group patients respectively and one early implant failure occurred in each group in addition to one further early failure recorded only in the delayed group.

Table 1: Baseline demographic and site characteristics by treatment group (n = 100)

Characteristic	Immediate Placement (n = 50)	Delayed Placement (n = 50)	P-value
Age (years), mean ± SD	44.94 ± 9.99	43.90 ± 12.07	0.640
Female sex, n (%)	26 (52.0)	19 (38.0)	0.159
Current smoker, n (%)	10 (20.0)	10 (20.0)	1.000
Anterior tooth region, n (%)	36 (72.0)	34 (68.0)	0.663
Bone quality D1–D4 (Lekholm & Zarb), distribution	D1:3 D2:16 D3:25 D4:6	D1:5 D2:15 D3:22 D4:8	0.799
Thin gingival biotype, n (%)	27 (54.0)	26 (52.0)	0.841
Buccal bone thickness (mm), mean ± SD	1.13 ± 0.32	1.11 ± 0.37	0.751
Implant length (mm), mean ± SD	10.81 ± 1.35	11.00 ± 1.41	0.493
Implant diameter (mm), mean ± SD	3.77 ± 0.31	3.80 ± 0.31	0.566
Primary stability – ISQ at placement, mean ± SD	68.50 ± 4.95	72.86 ± 5.33	<0.001

Table 2: Comparison of implant stability, radiographic, esthetic and patient-reported outcomes between immediate and delayed implant placement at 12 months ISQ, Implant Stability Quotient; VAS, Visual Analogue Scale

Outcome measure	Immediate Placement (n = 50)	Delayed Placement (n = 50)	P-value
ISQ at 3 months	72.92 ± 6.14	79.88 ± 5.93	<0.001
ISQ at 6 months	77.54 ± 6.66	83.42 ± 5.85	<0.001
Marginal bone loss at 6 months (mm)	0.53 ± 0.24	0.35 ± 0.20	<0.001
Marginal bone loss at 12 months (mm)	0.83 ± 0.31	0.63 ± 0.25	<0.001
Pink Esthetic Score at 12 months (0–14)	10.48 ± 1.50	11.34 ± 1.24	0.002
Patient satisfaction, VAS (0–10)	8.34 ± 1.02	8.60 ± 0.81	0.162
Soft tissue healing time (weeks)	14.02 ± 2.27	21.78 ± 3.21	<0.001
Implant survival at 12 months, n (%)	49 (98.0)	48 (96.0)	1.000

Discussion:

In this randomized controlled trial, immediate and delayed implant placement produced comparable, high implant survival at 12 months, consistent with pooled estimates from systematic reviews and meta-analyses reporting risk ratios close to unity between the two protocols. However, survival equivalence coexisted with clear differences in the trajectory of stabilization and in hard- and soft-tissue outcomes. Primary and secondary stability were significantly lower with immediate placement at

every time point measured, mirroring resonance-frequency-analysis studies that have consistently found lower ISQ values for implants placed into fresh extraction sockets compared with implants placed in healed bone, even though values in both groups remained within a range generally considered compatible with successful osseointegration [7]. The greater marginal bone loss observed with immediate placement is consistent with the more irregular peri-implant bony housing and the buccal plate remodeling that follows extraction and it

parallels the modestly lower Pink Esthetic Score recorded in the immediate group; comparable trends linking placement timing to esthetic and hard-tissue outcomes have been reported in prospective studies and systematic reviews of anterior-zone implants [8]. Despite these measurable differences, patient-reported satisfaction did not differ significantly between groups, suggesting that the shorter overall treatment time afforded by immediate placement may offset the marginally less favorable objective hard- and soft-tissue findings from the patient's perspective, a pattern also noted in prospective comparative studies of the aesthetic zone [9]. Smoking status was balanced between groups in this cohort and did not appear to drive the observed differences; nonetheless, smoking remains one of the most consistently identified patient-level risk factors for early implant failure across placement protocols and should be considered when individualizing the choice between immediate and delayed placement [10, 11]. Taken together, these findings support the view that the choice between immediate and delayed placement is less a question of achievable survival than of an individualized trade-off between treatment duration and the pace and completeness of peri-implant hard- and soft-tissue stabilization [12, 13].

Conclusion:

Immediate and delayed implant placement showed comparable implant survival at 12 months. Immediate placement reduced soft-tissue healing time but showed lower implant stability, greater marginal bone loss and slightly lowers esthetic scores. Treatment timing should therefore be individualized according to site anatomy, esthetic demands and patient preference.

Limitations:

This trial is limited to a 12-month follow-up period, which captures early stabilization and short-term survival but not longer-term bone remodeling or prosthetic complications. The trial was conducted at a single center and case selection

favoured sites with adequate bone volume for primary stability, which may limit generalizability to more compromised sites. Radiographic bone loss was assessed on periapical rather than three-dimensional imaging and esthetic assessment (Pink Esthetic Score) was confined to the 12-month timepoint. As reported here, the underlying dataset is a synthetic sample generated for illustration and statistical-workflow practice rather than a completed clinical trial; the manuscript text should be regarded as a reporting template to be re-populated with real trial data, author details and institutional information.

References:

- [1] Peitsinis PR *et al.* *J Clin Med.* 2025 **14**:1442. [PMID: 40094901]
- [2] <https://www.ncbi.nlm.nih.gov/books/NBK231759>
- [3] Patel R *et al.* *Dent J (Basel).* 2023 **11**:218. [PMID: 37754338]
- [4] https://en.wikipedia.org/wiki/Dental_implant
- [5] Pandya DJ *et al.* *Bulletin of Stomatology and Maxillofacial Surgery.* 2025 **21**:322. [DOI: 10.58240/1829006X-2025.21.7-322]
- [6] Rehberger Bescós F *et al.* *Int J Implant Dent.* 2025 **11**:25.[PMID: 40140226]
- [7] Seidel D *et al.* *J Clin Med.* 2025 **14**:3040. [PMID: 40364071]
- [8] Galindo-Moreno P *et al.* *Clin Implant Dent Relat Res.* 2022 **24**:630. [PMID: 35831919]
- [9] Yang Y *et al.* *Oral Health Prev Dent.* 2026 **24**:77.[PMID: 41665039]
- [10] Fan YY *et al.* *J Dent.* 2024 **151**:105396.[PMID: 39393606]
- [11] Elena C *et al.* *Clin Oral Implants Res.* 2026 **37**:262. [PMID: 41776304]
- [12] Alexandre P *et al.* *Applied Sciences.* 2023 **13**:9368. [DOI: 10.3390/app13169368]
- [13] Ickroth A & Cosyn J. *Clin Oral Implants Res.* 2025 **36**:64. [PMID: 39315690]

Caveat Emptor is applicable among the literate community where required and possible. The publisher, its journal, editors and the internal/external reviewers take adequate steps to check, evaluate, correct, edit, revise and improve content where possible and required.