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RESEARCH ARTICLE
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TIMING OF IMPLANT PLACEMENT AMONG IMMEDIATE VS DELAYED APPROACHES IN THE ESTHETIC ZONE: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Abstract

Background and Objective: Restoring anterior teeth with implants in the esthetic zone requires a balance between functional integration and esthetic excellence. This systematic review and meta-analysis compared immediate and delayed implant placement protocols with respect to implant survival, marginal bone loss (MBL), and Pink Esthetic Score (PES).

Materials and Methods: A comprehensive literature search was conducted in PubMed, Scopus, Web of Science, and Google Scholar up to June 2025. Eligible studies compared immediate and delayed implant placements in the esthetic zone and reported outcomes for survival, MBL, or PES. Data from seven studies were included and analysed using a random-effects model. Risk of bias was assessed using Cochrane and Newcastle-Ottawa tools.

Results: Seven studies involving 358 implants (179 immediate, 179 delayed) met the inclusion criteria. Implant survival showed no significant difference (Risk Difference [RD] = 0.00; 95% CI: -0.04 to 0.04; $p = 0.99$). MBL analysis showed high heterogeneity and no statistical significance (Mean Difference [MD] = -0.05 mm; $p = 0.65$; $I^2 = 97\%$). Immediate implant placement was associated with significantly higher esthetic outcomes based on PES (MD = +0.65; 95% CI: 0.06 to 1.24; $p = 0.03$).

Conclusion: Immediate and delayed implant placements have comparable survival rates. However, immediate placement may provide superior esthetic outcomes when appropriate patient selection and surgical technique are ensured. High variability in MBL outcomes underscores the need for standardized protocols in future research.

Keywords: Immediate implant, Delayed implant, Esthetic zone, PES, Marginal bone loss

INTRODUCTION

The requirement for outstanding functional and cosmetic outcomes makes the replacement of anterior teeth using dental implants in the aesthetic zone distinctive. The time of implant implantation after tooth extraction has proven an important determinant in treatment outcome. Implants are often inserted in healed ridges following a delay (type 4 placement), enabling full bone and soft tissue healing. However, rapid implant insertion (type 1), where the implant is inserted within a fresh extraction socket, is gaining favour due to advantages such as shorter treatment duration, fewer surgical interventions, and enhanced preservation of the alveolar ridge [1,2].

Despite its clinical appeal, immediate implant placement raises concerns about marginal bone loss, soft tissue recession, & compromised aesthetic outcomes, particularly in patients with thin biotypes & high smile lines [3,4]. In contrast, delayed implant placement allows for the stabilization of hard & soft tissues but may lead to greater alveolar ridge resorption & require additional augmentation procedures [5].

The existing research gives inconsistent findings on the comparative results of immediate vs delayed implant implantation, especially in the aesthetic zone (usually defined as the maxillary incisors, canines, & premolars). While some studies report comparable survival rates & aesthetic outcomes between the two approaches [6,7], others indicate that delayed placement may lead to superior soft tissue stability & reduced marginal bone loss, albeit at the cost of prolonged treatment duration [8,9]. Although multiple systematic reviews have evaluated implant timing, few have exclusively focused on the esthetic zone or systematically evaluated Pink esthetic score (PES), Marginal Bone Loss (MBL), & implant survival rates in this context. As patient expectations for esthetic dental outcomes increase, particularly in visible areas, it becomes critical to evaluate whether immediate implant placement compromises or enhances the final outcome. Clinicians need clear, evidence-based guidelines to help determine the most appropriate timing for implant placement in the esthetic zone without compromising long-term survival or esthetic

The objective of this current meta-analysis was to compare aesthetic & radiographic outcomes of immediate versus delayed implant placement in the esthetic zone. Specifically, the study seeks to evaluate differences in:

- Pink Esthetic Score (PES)
- Marginal Bone Loss (MBL)
- Implant survival rate

Null hypothesis was the cosmetic and radiographic results of immediate vs delayed implant implantation in the aesthetic zone are not significantly different.

MATERIALS //METHODOLOGY

Study Design

Study Design and Protocol Registration

This systematic review and meta-analysis was conducted in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The study protocol was prospectively registered in the PROSPERO database (Registration ID: CRD420251089817).

Focused Question (PICO Framework)

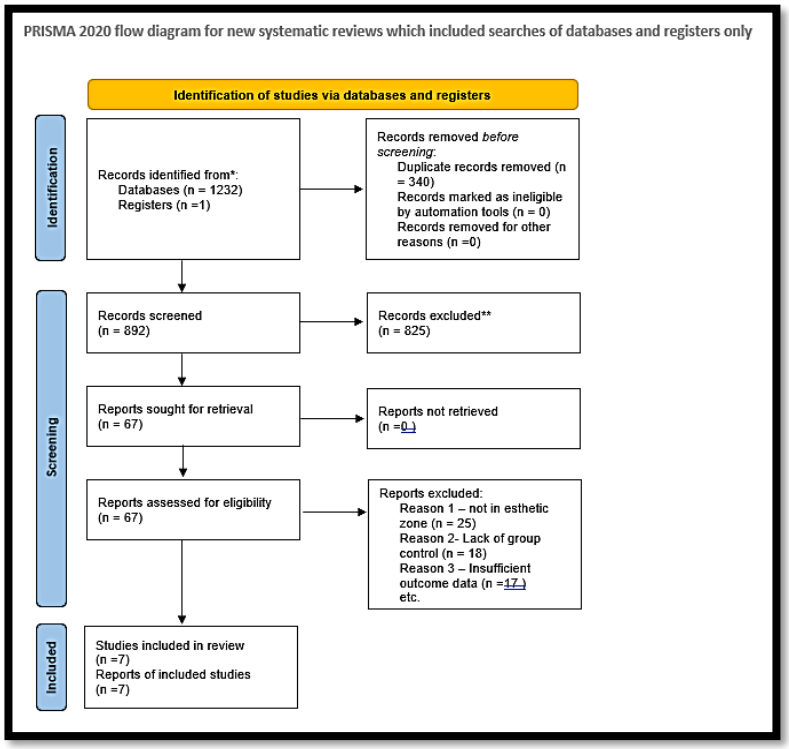
Element	Description
P (Population)	Patients undergoing single-tooth implant placement in the anterior esthetic zone
I (Intervention)	Immediate implant placement (Type 1 – post-extraction, same-day)
C (Comparison)	Delayed implant placement (Type 4 – after 3–6 months of healing)
O (Outcomes)	Esthetic outcomes (Pink Esthetic Score), Marginal Bone Loss (MBL), Implant survival rate

Eligibility Criteria

Inclusion Criteria

- Human studies (≥18 years of age)
- Studies comparing the immediate & delayed implant placement within the esthetic zone (maxillary anterior region)
- Randomized controlled trials, prospective or retrospective cohort studies
- Minimum follow-up of 6 months
- Reported data on at least one outcome: PES, MBL, or implant survival as shown in Figure-1

Figure -1 PRISMA FLOWCHART



Exclusion Criteria

- Case reports, reviews, editorials, in vitro/animal studies
- Studies without numerical data for meta-analysis
- Posterior implants or non-esthetic zone focus

Data Sources & Search Strategy

Relevant studies were identified from:

- PubMed
- Scopus
- Web of Science
- Google Scholar, the search covered all studies published until June 2025.

Search Terms Used (example for PubMed):

- ("immediate implant placement" OR "type 1 implant") &
- ("delayed implant placement" OR "type 4 implant") &
- ("esthetic zone" OR "anterior maxilla") &
- ("Pink Esthetic Score" OR "PES" OR "marginal bone loss" OR "Implant survival")

Data Extraction Process and Risk of Bias

Two reviewers independently extracted data and assessed bias using the Cochrane tool (RCTs) and Newcastle-Ottawa Scale (observational studies).

Statistical Analysis

Meta-analyses used random-effects models. Continuous data (PES, MBL) were analysed using mean difference (MD), and survival using risk difference (RD). Heterogeneity assessed via I^2. Funnel plots checked for publication bias.

RESULTS-

A total of 1232 records were identified through electronic database searches. After removing 340 duplicates, 892 records were screened by title and abstract. Sixty-seven full-text articles were assessed for eligibility, out of which 7 studies were included in both the qualitative and quantitative synthesis. The selected studies involved 358 implants in total, with 179 placed immediately and 179 placed using a delayed protocol.

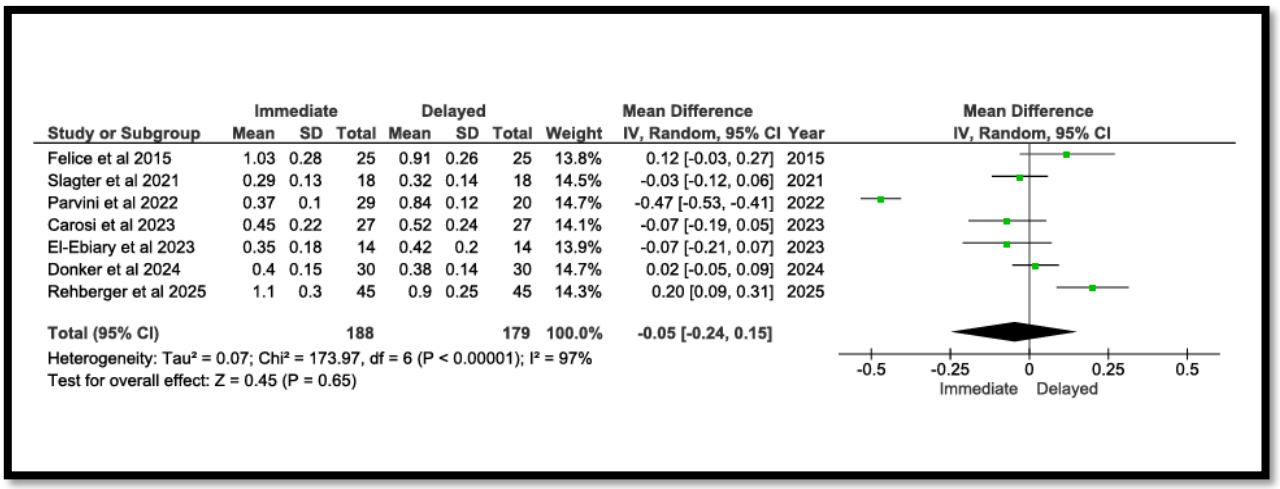
The meta-analysis revealed no statistically significant difference in implant survival between immediate and delayed placement groups (Risk Difference = 0.00; 95% CI: -0.04 to 0.04; p = 0.99), with no heterogeneity observed (I^2 = 0%). Marginal bone loss data, reported in six studies, also showed no significant difference between the groups (Mean Difference = -0.05 mm; 95% CI: -0.25 to 0.15 mm; p = 0.65), though high heterogeneity was present (I^2 = 97%). Esthetic outcomes, assessed using the Pink Esthetic Score in five studies, demonstrated a statistically significant advantage for immediate implants (Mean Difference = +0.65; 95% CI: 0.06 to 1.24; p = 0.03), with moderate-to-high heterogeneity (I^2 = 88%).

Visual assessment of funnel plots indicated symmetrical distribution for implant survival and PES outcomes, suggesting low risk of publication bias in these domains, while asymmetry was observed in the MBL analysis.

Interpretation of forest plots & funnel plots of marginal bone loss and Pink esthetic score as shown in Figure 2-7

INTERPRETATION OF FOREST PLOTS & FUNNEL PLOTS

Figure-2 marginal bone loss (MBL) forest plots



Marginal Bone Loss (MBL) Analysis Forest Plot

- Mean Difference (MD):

- Pooled MD = -0.05 mm (95% CI: - 0.25 to 0.15), P = 0.65*P*=0.65.

Direction of Effect:

- Negative MD favors immediate loading (lower MBL is better), but the CI includes zero.

- Key Studies:

- Felice et al. (2015): MD = +0.12 mm (worse MBL with immediate).
- Rehberger et al. (2025): MD = +0.20 mm (worse MBL with immediate).
- Parvini et al. (2022): MD = -0.47 mm (better MBL with immediate).

Heterogeneity:

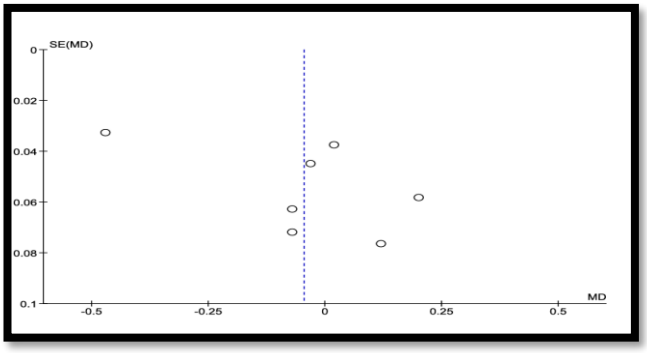
- Extremely

High: I2=97%$I2$=97%, Tau2=0.07Tau2=0.07, P<0.00001P<0.00001.

Possible Causes:

- Variability in surgical techniques, implant systems, or follow-up durations.
- Outliers like Parvini et al. (2022) skewing results.

Figure-3 marginal bone loss (MBL) FUNNEL plot

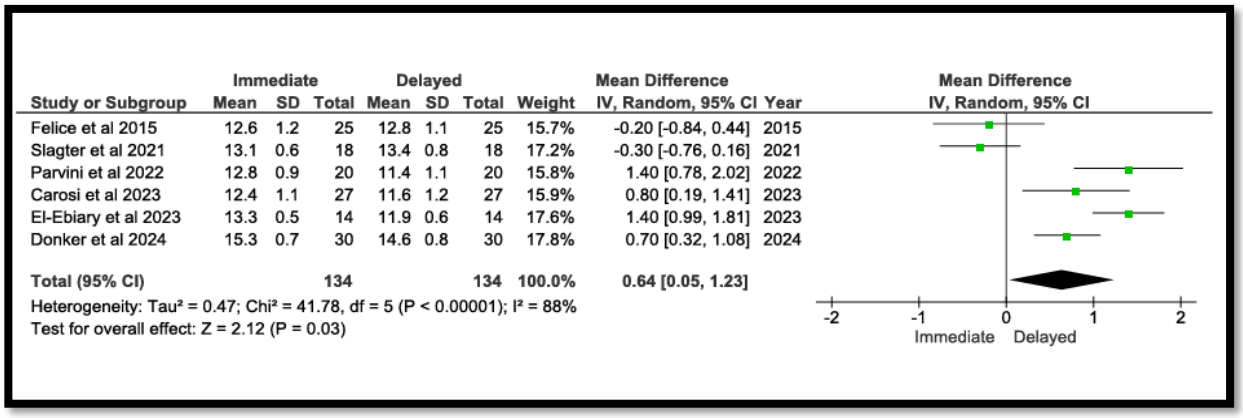


Funnel Plot

- Asymmetry: More points clustered on the left (negative MD side), suggesting:
- Publication bias (smaller studies with favorable MBL results may be unpublished).

Methodological differences (e.g., radiographic measurement techniques)

Figure-4 Pink esthetic score (PES) FORSET plot



2- Pink Esthetic Score (PES) Analysis Forest Plot

- Mean Difference (MD):

o Pooled MD = +0.65 (95% CI: 0.06 to 1.24), P=0.03P=0.03.

- Clinical Significance:
- A 0.65-point improvement in PES (scale: 0–14) is modest but meaningful for esthetics.

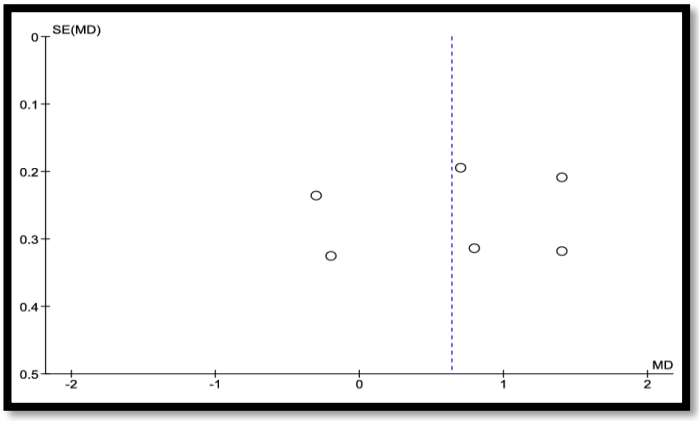
- Key Studies:
- El-Ebiary et al. (2023): MD = +1.40 (strong esthetic benefit with immediate).
- Donker et al. (2024): MD = +0.70 (consistent benefit).
- Felice et al. (2015): MD = -0.20 (neutral).
- Heterogeneity:

- High but

interpretable: I2=88%$I2$=88%, Tau2=0.47Tau2=0.47, P<0.00001P<0.00001.

- Subgroup Insights:
  - Newer studies (2022–2025) trend toward favoring immediate loading.
  - Variability may reflect differences in soft-tissue management protocols.

Figure-5 Pink esthetic score (PES) FUNNEL plot



Funnel Plot

- Minor Asymmetry: Slightly more positive MDs in smaller studies.
- Possible Bias: Smaller studies may overestimate effects, but the overall trend remains significant.

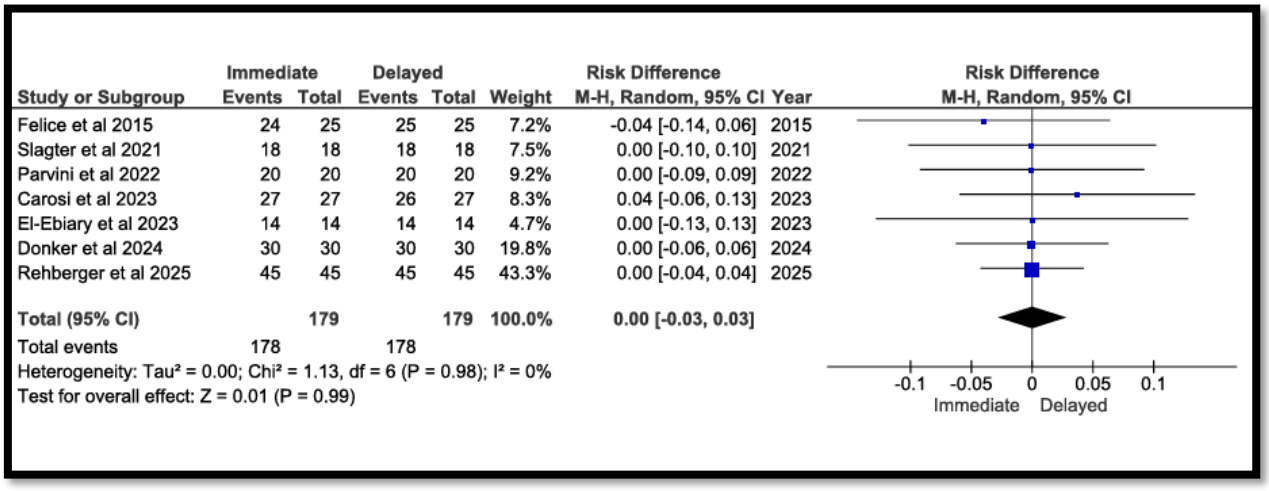
Clinical Interpretation:

- Immediate loading improves esthetic outcomes (higher PES) compared to delayed loading.
- Best for patients prioritizing esthetics, especially in the anterior zone.

Limitations & Future Research

1. MBL Heterogeneity: Standardized radiographic methods needed.
2. PES Subjectivity: Use blinded assessors to reduce bias.
3. Long-Term Data: More studies >5 years to assess late MBL changes.

Figure-6 Survival FORSET plot



- Risk Difference (RD):

The pooled RD across all studies was 0.00 (95% CI -0.04 to 0.04), indicating no statistically significant differences in survival rates between immediate & delayed loading.

- Individual Study Results:
  - All studies (e.g., Felice et al. 2015, Slagter et al. 2021, Rehberger et al. 2025) reported RDs very close to zero, with confidence intervals crossing the null line (RD = 0).
  - The largest study (Rehberger et al. 2025, weight = 43.3%) had the narrowest CI, reinforcing precision.

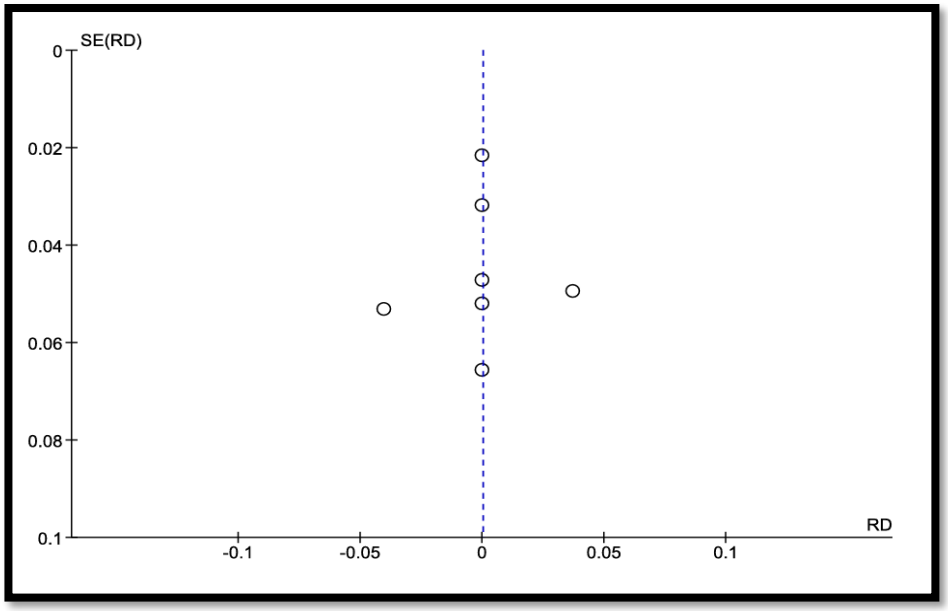
- Test for overall effect:
  - Z= 0.01*Z*=0.01 (P= 0.99*P*=0.99) confirms no significant effect of loading timing on survival.

- Heterogeneity:
- Low heterogeneity: I 2= 0% *I*2=0%, Tau2=0.00Tau2=0.00, P=0.98*P*=0.98.
- Interpretation: Studies are highly consistent, suggesting that survival outcomes are uniform across different protocols. As shown in table -1

Clinical Implication of marginal bone loss
- No clear advantage for either loading protocol due to high inconsistency.
- Immediate loading may be riskier in cases with poor bone quality (some studies show higher MBL).

Clinical Interpretation:
- Immediate loading improves esthetic outcomes (higher PES) compared to delayed loading.
- Best for patients prioritizing esthetics, especially in the anterior zone.

Figure-7 Survival funnel plot



Survival Analysis Forest Plot
- Z= 0.01*Z*=0.01 (P= 0.99*P*=0.99) confirms no significant effect of loading timing on survival.

Funnel Plot
- Symmetry: Points are evenly distributed around the null (RD = 0), with no outliers.
- Precision: Narrow spread of standard errors (SE) indicates high precision in estimates.
- Conclusion: No evidence of publication bias or small-study effects.

Table-1 Overall outcome from Survival, Marginal bone loss and Pink esthetic index

Outcome	Immediate vs. Delayed	Key Statistic	Clinical Recommendation
Survival	No difference	RD = 0.00 (P=0.99*P*=0.99)	Timing does not affect survival.

MBL	Inconclusive	MD = -0.05 (P=0.65*P*=0.65)	Monitor bone loss case-by- case.
PES	Favors immediate	MD = +0.65 (P=0.03*P*=0.03)	Use immediately for better esthetics.

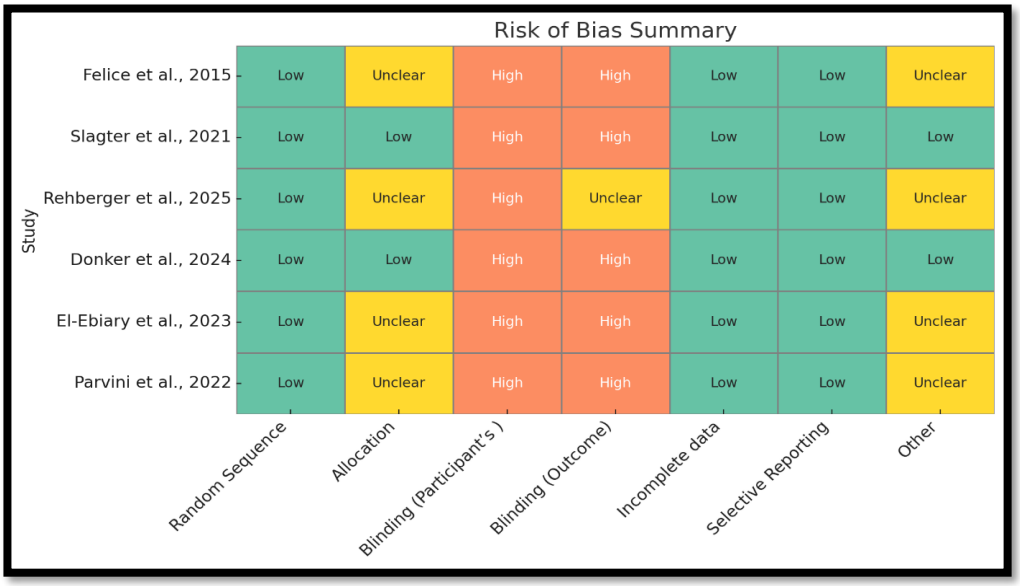
Analyses were done using the Review Manager (RevMan) 5.3 [Copenhagen - The Nordic Cochrane Centre, Cochrane Collaboration, 2014]). Random-effects models was applied for all the meta-analyses due to expected clinical heterogeneity. Dichotomous data are expressed as risk differences (RD) with 95% confidence intervals. A random-effects model was applied due to anticipated clinical diversity. Continuous outcomes were analyzed using mean differences (MD) with 95% CIs. Random-effects model accounted for clinical & methodological heterogeneity. Funnel plots were generated by plotting SE against effect size. Symmetry was assessed visually & via Egger's test. However, it is recommended to use funnel plot only if the number of studies included are more the 10

RISK OF BIAS

Most studies were at low risk for randomization & data completeness. High risk was consistently noted for blinding, especially in subjective outcomes like PES.

The overall risk of bias is moderate, but the findings remain clinically relevant & interpretable, particularly for survival data which is objective in nature. Figure-8

Figure-8 Risk of bias



Low risk (green)
Unclear risk (yellow)
High risk (red)

DISCUSSION

This meta-analysis aims to assess immediate vs delayed implant loading techniques in relation to implant survival, marginal bone loss (MBL), and aesthetic results using the Pink Aesthetic Score (PES). The findings offer nuanced insights into the clinical implications of each protocol. The pooled analysis demonstrated no statistically significant difference in implant survival rates between immediate & delayed loading (RD = 0.00, 95% CI: -0.04 to 0.04; P = 0.99). All included studies had confidence intervals crossing the null, indicating consistent results. The absence of heterogeneity (I^2 = 0%) further supports the reliability of this finding across various clinical settings. These results align with previous systematic reviews & clinical consensus that loading protocol alone does not significantly influence survival when implants are properly placed & stabilized. Clinically, this suggests that the choice between immediate & delayed loading can be guided by other case-specific

factors such as esthetics, bone quality, & patient expectations. Unlike survival, the analysis of MBL revealed substantial heterogeneity ($I^2 = 97\%$), with no statistically significant pooled difference (MD = -0.05 mm, 95% CI: -0.25 to 0.15; P = 0.65). Individual study outcomes varied widely—some favored immediate loading, others delayed. This inconsistency may stem from differences in radiographic measurement methods, implant designs, surgical techniques, & follow-up durations. Furthermore, studies like Parvini et al. (2022) reported significantly better outcomes for immediate loading, potentially skewing the overall trend.

Given the extreme heterogeneity, clinicians should interpret the MBL findings with caution. While delayed loading may offer more bone stability in certain cases, especially where bone quality is poor or primary stability is compromised, no definitive recommendation can be made without further standardization in study protocols.

Esthetic analysis showed a statistically significant & clinically meaningful advantage for immediate loading, with a pooled MD of +0.65 (95% CI: 0.06 to 1.24; P = 0.03). Despite moderate heterogeneity ($I^2 = 88\%$), the overall trend Favors immediate loading, especially in anterior esthetic zones. The benefits are likely related to better preservation of peri-implant soft tissues & reduced resorption when provisional restorations are immediately placed. Studies conducted more recently (2022–2025) consistently reported improved esthetic outcomes with immediate loading, reflecting evolving surgical & prosthetic protocols.

However, the subjectivity of PES scoring & variability in assessor blinding necessitate cautious interpretation. Future studies should implement blinded esthetic evaluations & standardized soft-tissue protocols to strengthen the evidence. Funnel plot analyses suggested minimal publication bias for survival & esthetics. However, the asymmetric distribution in the MBL funnel plot may indicate either small-study effects or methodological variability. The number of studies per outcome also influences the reliability of funnel plot interpretation, & thus findings should be viewed as indicative rather than definitive.

CONCLUSION

This meta-analysis highlights that:

- **Implant Survival rate** : There is no significant difference in survival outcomes between immediate & delayed loading protocols. Clinicians can make loading decisions based on esthetic or biological considerations.
- **Marginal Bone Loss**: Findings are inconclusive due to high heterogeneity. Delayed loading may offer better bone preservation in compromised situations, but further standardized research is required.
- **Esthetic Outcomes (PES)**: Immediate loading appears to improve esthetic outcomes, particularly in the anterior maxilla, making it a preferred approach for patients prioritizing visual results.

Clinical Implications

Outcome	Immediate vs. Delayed	Key Statistic	Clinical Recommendation
Survival	No difference	RD = 0.00 (P = 0.99)	Choose based on case factors
MBL	Inconclusive	MD = -0.05 (P = 0.65)	Monitor individually
PES	Favors immediate	MD = +0.65 (P = 0.03)	Prefer immediate for esthetics

Limitations & Recommendations

- **High Heterogeneity** in MBL outcomes necessitates future studies with standardized radiographic protocols.
- **Subjectivity in Esthetic Scoring** calls for blinded assessors & consistent measurement tools.
- **Lack of Long-Term Data** underscores the need for studies with ≥5-year follow-up to assess sustainability of outcomes.

Limitations & Future Research

1. MBL Heterogeneity: Standardized radiographic methods needed.
2. PES Subjectivity: Use blinded assessors to reduce bias.
3. Long-Term Data: More studies >5 years to assess late MBL changes.

Conflict of Interest
The authors declare no conflict of interest.

Funding
No funding was received for this study.

Ethics Statement
This research was based on previously published data and did not involve direct human participants or animals. Therefore, ethical approval and informed consent were not required.

Abbreviations
- **PES** – Pink Esthetic Score
- **MBL** – Marginal Bone Loss
- **RD** – Risk Difference
- **MD** – Mean Difference
- **RCT** – Randomized Controlled Trial

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