

Immediate Versus Early Loading of Single Dental Implants: A Systematic Review and Meta-Analysis

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Abstract:

Background: Immediate loading of single-tooth dental implants offers the potential for reduced treatment time and early restoration of function and esthetics. However, concerns regarding implant survival and marginal bone loss compared with early loading remain. This systematic review and meta-analysis aimed to evaluate and compare the effectiveness of immediate loading and early loading protocols for single-tooth dental implants.

Materials and Methods: A systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A focused PICO question was formulated to compare immediate loading with early loading of single-tooth dental implants, with implant survival rate and marginal bone loss as the primary outcomes. PubMed, Google Scholar, and EBSCOhost databases were searched for studies published from January 2000 to December 2024. Randomized controlled trials, prospective studies, and retrospective studies published in English and providing comparative outcome data were considered eligible. Two reviewers independently screened the retrieved articles and extracted relevant data. Risk of bias was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool. Meta-analysis was performed using risk ratio (RR) for survival and standardized mean difference (SMD) for marginal bone loss, with statistical significance set at $p < 0.05$. Heterogeneity, publication bias, certainty of evidence, and sensitivity analysis were also assessed.

Results: Of 250 identified records, five randomized controlled trials involving 256 patients and 454 implants were included. Follow-up ranged from 12 to 60 months. Survival rates were 96–100% for both loading protocols. At 1 year, the pooled RR for survival was 1.02 (95% CI: 0.15–6.98; $p > 0.05$), and at 3 years, 0.94 (95% CI: 0.06–14.27; $p > 0.05$). For marginal bone loss, the SMD was 0.31 (95% CI: 0.04–0.65; $p > 0.05$) at 1 month and –0.45 (95% CI: –0.91–0.00; $p = 0.05$) at 3 months.

Conclusion: Immediate and early loading demonstrated comparable implant survival in single-tooth implants. No significant difference in survival was observed at 1 or 3 years. Differences in marginal bone loss were observed at the evaluated time points. Further well-designed trials with standardized protocols and longer follow-up are warranted.

Key Word: Immediate loading; early loading; single-tooth dental implant; implant survival; marginal bone loss; systematic review; meta-analysis.

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I. Introduction

Since beginning of early eighties in the 20th century, treatments with dental implants are routine method of rehabilitation edentulous and partially edentulous jaws.¹ The two-stage loading protocol presented by Branemark (1977) involves healing period of 3–6 months. A healing period without stress was recommended in the order to present better survival rate.²

Since 1990, implants placed in completely edentulous mandibles have been loaded immediately or early in selected patients.³ For single implant-supported crowns, similar success rates have been reported for both protocols and for conventional loading protocol, especially when implants are placed with adequate length.⁴

A prospective cohort trial with early loaded single implants determined a marginal bone loss of 0.42 mm and a survival rate of 94.44% after 3 years for maxillary anterior teeth.⁵ Similar results were stated by a prospective clinical trial with a marginal bone loss of 0.97 mm and a survival rate of 94% for early loaded single maxillary implants.⁶ Both studies concluded that an early loading protocol was safe and predictable for patients.⁷ Another retrospective study of single implants, anterior and premolar maxillary crowns, loaded immediately reported a marginal bone loss of 0.33 mm (mesially) and 0.28 mm (distally) and a survival rate of 86.4% after 2.5 years.⁸

The conventional two-stage loading protocol has been recommended for dental implants with polish, machined, and first version of rough surfaces.⁹ Shorter healing period was presented in many experimental and clinical studies using SLA surfaces.¹⁰

Concerning the insertion period, loading can be immediate or late.¹¹ Immediate prosthetic reconstruction is in the first 48 h after implant placement and can be immediate functional loading or nonfunctional IL (termed immediate restoration).¹² Late prosthetic reconstruction has been termed as early loading (EL), conventional, and delayed loading.¹³

Stable bone-implant contact without micromovements is the most important for future osseointegration.¹² Early after insertion, primary implant stability is only mechanical. During the healing period, it converts to combination form of mechanical and biological stability.¹³

Traditionally, osseointegrated dental implants were submerged and kept load-free for 3–8 months to minimize the risk of implant failures.¹⁴ It would be beneficial to reduce the healing period without jeopardizing implant success and nowadays immediate and early loaded implants are commonly used.¹⁵ A systematic review revealed no significant difference between immediate and early loaded implants.¹² In any case, there are few RCTs that evaluate the radiographic outcome between immediate and early loaded implants.¹³

We updated our research for related articles and conducted a systematic review with the aim to provide an updated evidence on effectiveness of immediate loading compared to early loading for single dental implant with the hypothesis of study aimed to evaluate whether immediate implant loading could be an ideal alternative to early implant loading for single tooth dental implant.

II. Material And Methods

Study design

Focused research question in the Participants (P), Intervention (I), Comparison (C) and Outcome (O) format was proposed “Is there any difference in effectiveness of immediate loading compared to early loading for single tooth dental implant?”

P – patients requiring dental implants

I – immediate implant loading

C – early implant loading

O – survival rate and marginal bone loss (MBL)

Eligibility Criteria:

a) Inclusion Criteria:

- 1) Studies published in English language and from open access journals
- 2) Studies published from January 2000 – December 2024
- 3) Studies having sufficient comparative data on the effectiveness of immediate loading compared to early loading for single tooth dental implant
- 4) Studies reporting outcomes as survival rate and marginal bone loss
- 5) Randomized controlled trial (RCT), retrospective and prospective studies were selected

b) Exclusion Criteria:

- 1) Any studies conducted before 2000
- 2) Articles in other than English language
- 3) reviews, abstracts, letter to the editor, editorials, animal studies and in vitro studies were excluded
- 4) Articles not from open access journals

Search Strategy

Database search was performed till December 2024 for studies published within the last 24 years: PubMed, google scholar and EBSCOhost.

Key words and Medical Subject Heading (MeSH) terms were selected and combined with Boolean operators like AND/OR as shown below

Search Strategy according to PICO Format:

	Strategy
Population	"Dental implant"[MeSH Terms] OR "single tooth implant" OR "maxilla AND mandible" OR "function"[MeSH Terms] OR "load"
Intervention	("immediate implant placement"[MeSH Terms] OR ("single dental implant" AND "osseointegration" AND "implant stability" OR "success rate" OR "bone loss"
Comparator	("connective tissue graft" OR ("single dental implant" AND "osseointegration" AND "implant stability" OR "success rate" OR "bone loss"
Outcome assessed	("survival rate"[MeSH Terms] OR "marginal bone loss" OR ("implant success"[MeSH Terms] OR ("implant failure") AND ("comparative study") AND "randomized controlled trial" AND "prospective study")

Screening Process

A rigorous two-phase screening process was conducted by two authors to select relevant articles. Initially, titles and abstracts were reviewed, and non-relevant articles were excluded. Same reviewers independently performed the review of full text articles, with disputes resolved through discussion. A third reviewer was consulted when necessary to ensure consensus.

Data extraction

For included studies, descriptive data was extracted under following heading: author(s), country of study, year of study, sample size, study design, mean age of participants, follow up duration (months), implants loaded (immediate and early) and conclusion.

Quality assessment of studies

Quality assessment was performed by using Cochrane collaboration risk of bias (ROB) -2 tool¹⁷ through its various domains in Review Manager (RevMan) 5.3 software.

Statistical analysis

Statistical analysis was performed with risk ratio (RR) and standardized mean difference (SMD) serving as the summary measure. Significance was determined at the threshold of $p < 0.05$.¹⁸

Assessment of heterogeneity

The Cochran's test for heterogeneity was employed to assess the significance of any differences in treatment effect estimations among trials. Heterogeneity was deemed statistically significant if the P-value was < 0.01 .¹⁹

Investigation of publication bias

The study assessed publication bias using Begg's funnel plot, which plots the effect size against standard error. Asymmetry in the funnel plot may indicate potential publication bias.²⁰

Certainty of evidence

The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) was used to assess the quality of evidence based on: study design, ROB, consistency, directness, heterogeneity, precision, publication bias, and other aspects reported by studies.²¹

Sensitivity analysis

Meta-analysis increases the precision and power of the effects of an intervention but it may also lead to overestimation of the effects leading to type I i.e. false positive or type II false negative errors. Trial Sequential Analysis (TSA) was performed for a reliable and conservative assessment of the cumulative effects of interventions using Version 0.9 beta, Copenhagen Trial Unit, Centre for Clinical Intervention Research was used to conduct the TSA.²²

III. Result

Study Selection

After database search (n=250), duplicates removal and putting all inclusion and exclusion criteria's, in the end five studies were included in for qualitative synthesis and for quantitative synthesis as illustrated in Figure 1.

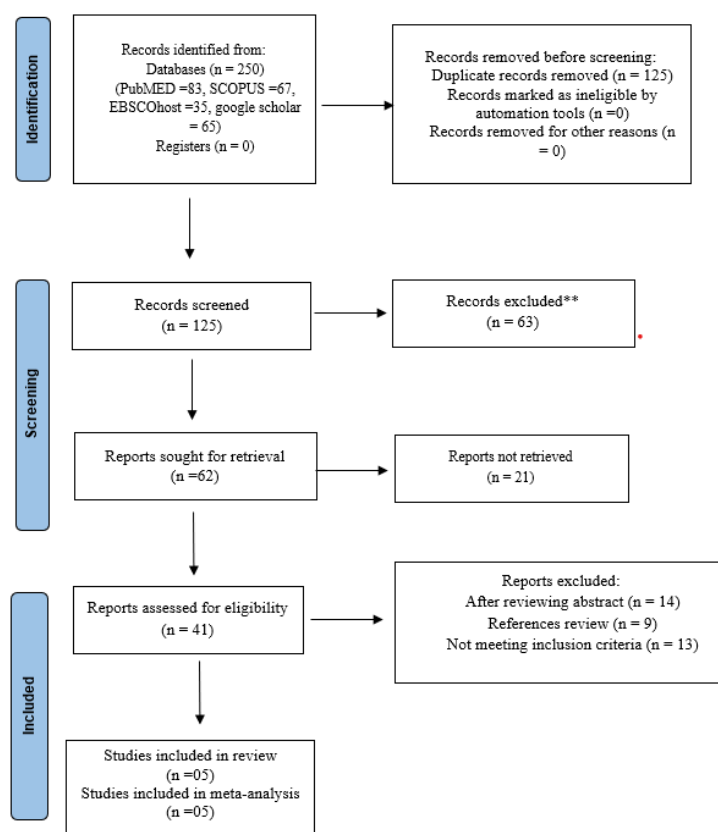


Figure 1. PRISMA 2020 Flow Diagram

Study Characteristics

As shown in **table 1 (a) and (b)**, data was evaluated from five studies²³⁻²⁷ from an aggregate of 256 patients who underwent single tooth implant placement. All the included studies had randomized controlled trial (RCT) study design with a mean follow up duration ranging from 12 – 60 months. Among the included studies, three studies^{24,25,27} were conducted in Italy, and one study each in Sweden²³ and Switzerland²⁶ 23 with a total of 241 implants loaded immediately while 213 implants were loaded early. Survival rate for immediate loaded implants ranged from 96 – 100% while the early loaded implants had survival rate ranging from 96 – 100%.

Table 1(a): Descriptive study characteristics of included studies

Author, years of study	Country	Follow up duration (months)	Sample size	Mean age (years)	Study design	Immediate implants loaded	Early implants loaded
Barkvui et al., 2012 ²³	Sweden	36	40	20 – 82	RCT	8 initial and 7 after 3 years	17
Cannizzaro et al., 2012 ²⁴	Italy	48	30	18 – 57	RCT	29 initial and 28 after 1 year	31 initial and 30 after 1 year
Merli et al., 2012 ²⁵	Italy	12	105	21- 73	RCT	35 initial and 32 after 1 year	35 initial and 34 after 1 year
Kokovic et al., 2014 ²⁶	Switzerland	60	12	20 – 62	RCT	36	36
Grandi et al., 2015 ²⁷	Italy	36	69	19 – 72	RCT	35 initial and 31 after 3 year	34 initial and 26 after 3 year

Table 1(b): Descriptive study characteristics of included studies

Author, years of study	Implant sites	Survival rate (immediate loading)	Survival rate (delayed loading)	Marginal bone loss (immediate loading)	Marginal bone loss (early loading)
Barewal et al., 2012 ²³	Maxilla: I=1; E=10; mandible: I=7; E=8; molar: I=3; E=8; premolar: I=5; E=10	100%	100%	Mesial -0.37 +/- 0.38; distal -0.29 +/- 0.37	Mesial -0.20 +/- 0.29; distal -0.13 +/- 0.27
Cannizzaro et al., 2012 ²⁴	Maxilla: I=17; E=16; inserted in fresh extraction sockets: I=9; E=9; elevated flap: I=8; E=5; incisor sites: I=2; E=1; canine sites: I=2; E=2; premolar sites: I=11; E=14; molar sites: I=15; E=13	96.55%	96.77%	-0.37 +/- 0.35;	-0.31 (SD 0.36);
Merli et al., 2012 ²⁵	Mandibles: I=7; E=13; incisor sites: I=8; E=3; canine sites: I=2; E=1; premolar sites: I=22; E=16; molar sites: I=3; E=15; non-augmented extraction sockets: I=4; E=1; augmented extraction sites: I=21; E=11	96.87%	96.55%	0.15 +/- 0.27	0.31 +/- 0.60
Kokovic et al., 2014 ²⁶	Posterior edentulous mandible	100%	100%	0.01 +/- 0.18	0.08 +/- 0.31
Grandi et al., 2015 ²⁷	Inserted in fresh extraction socket: I=13; E=16; inserted in fresh extraction site filled with Bio-Oss: I=8; E=7; inserted in mandible: I=12; E=13; In anterior area: I=2; E=5	100%	100%	1.91 +/- 0.72	1.59 +/- 0.76

Quality assessment

The high ROB was seen for bias due to missing outcome data followed by selection bias. All of the included studies reported moderate to lowest ROB. Bias due to deviations from intended deviations, bias in outcome measurement were given the lowest ROB by included studies as depicted in Figure 2 and 3.

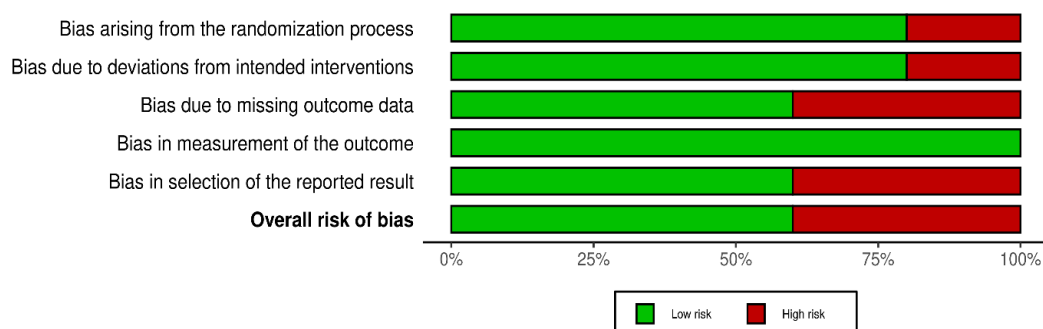


Figure 2: ROB: shown as percentages across all included studies.

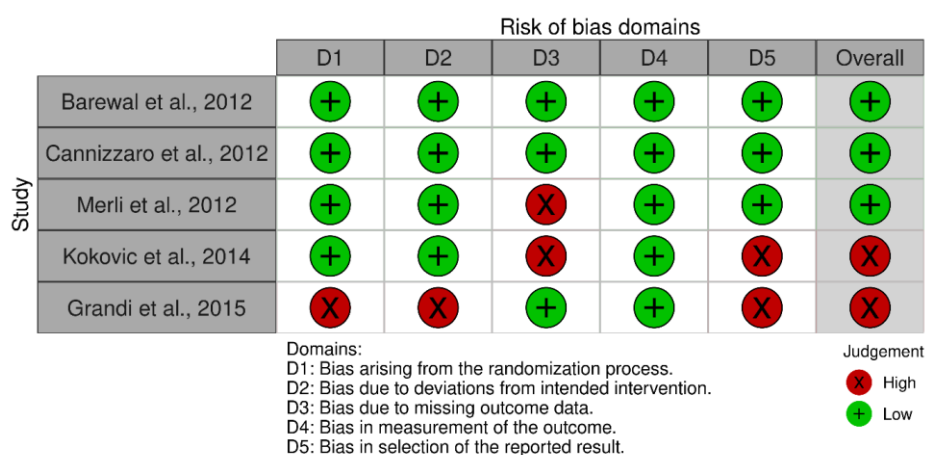


Figure 3: ROB summary: for each study

Synthesis of results/Meta-analysis

Effectiveness between immediate loading and early loading for single tooth implant was evaluated for survival rate and marginal bone loss as shown in figures 4-11.

A) Survival rate at 1 year

Five studies^{23,27-29} containing data on 287 implants loaded, of which ($n=147$) implants were loaded early and ($n=140$) implants loaded immediately for survival rate at 1 year. As shown in **Figure 4**, the RR is 1.02 (0.15 – 6.98) signifying that survival rate at 1 year on an avg. was 1.02 times more with immediate loading ($p>0.05$).

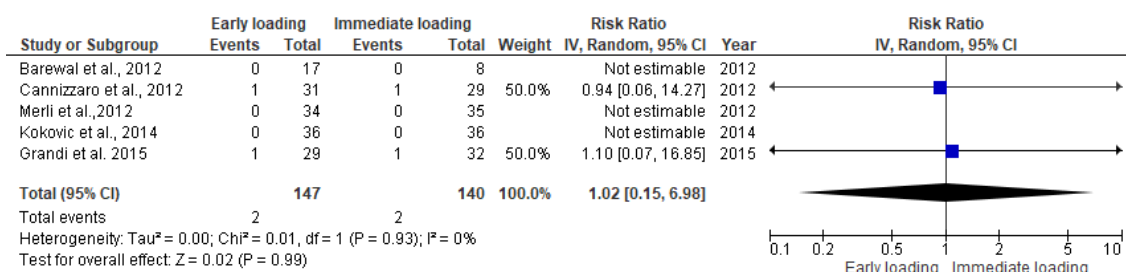


Fig 4: survival rate at 1 year

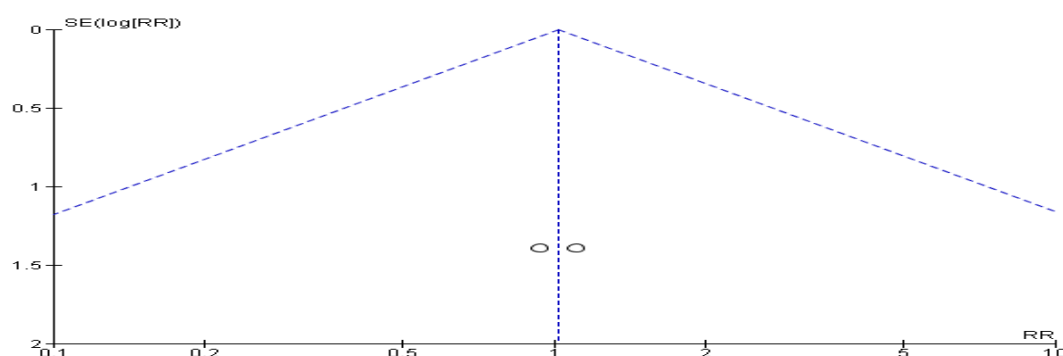


Fig 5: funnel plot showing absence of possible publication bias

B) Survival rate at 3 years

Five studies^{23,27-29} containing data on 213 implants loaded, of which ($n=110$) implants were loaded early and ($n=103$) implants loaded immediately for survival rate at 3 year. As shown in Figure 6, the RR is 0.94 (0.06 – 14.27) signifying that survival rate at 1 year on an avg. was 0.94 time more with immediate loading ($p>0.05$).

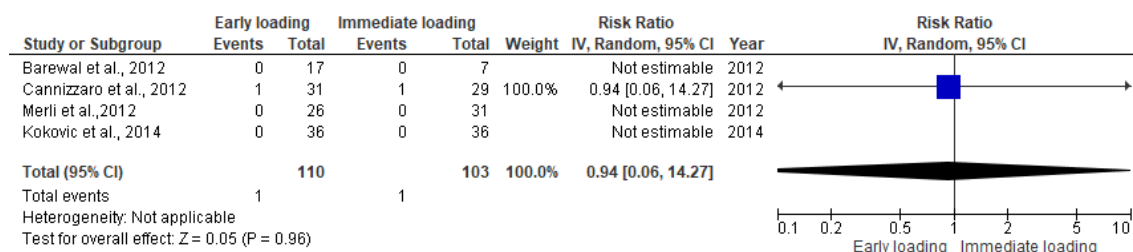


Fig 6: survival rate at 3 years

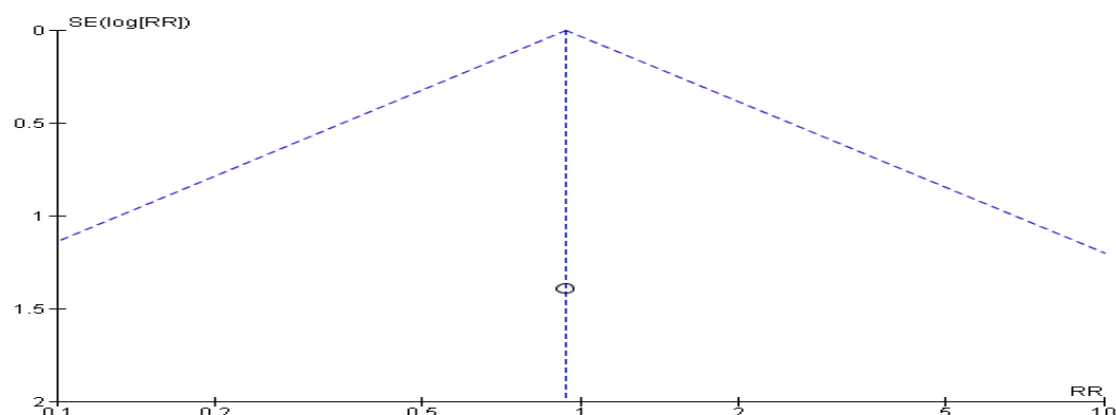


Fig 7: funnel plot showing absence of possible publication bias

C) Marginal bone loss (mm) at 1 month

Two studies^{26,27} containing data on 131 implants loaded, of which (n=64) implants were loaded early and (n=103) implants loaded immediately for MBL at 1 year. As shown in Figure 8, the SMD is 0.31 (0.04 – 0.65) signifying that MBL at 1 month on an avg. was 0.33 mm more with early loading ($p>0.05$).

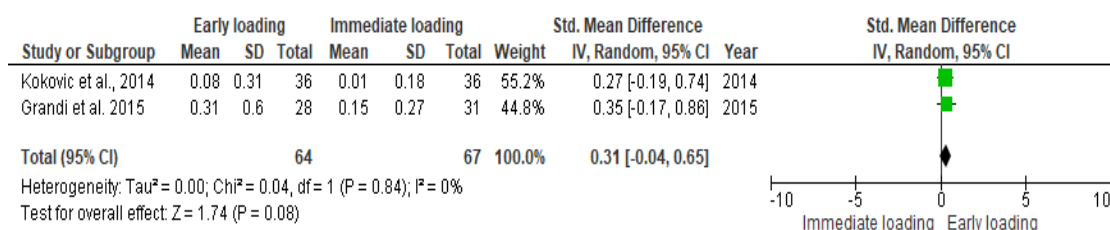


Fig 8: marginal bone loss at 1 month

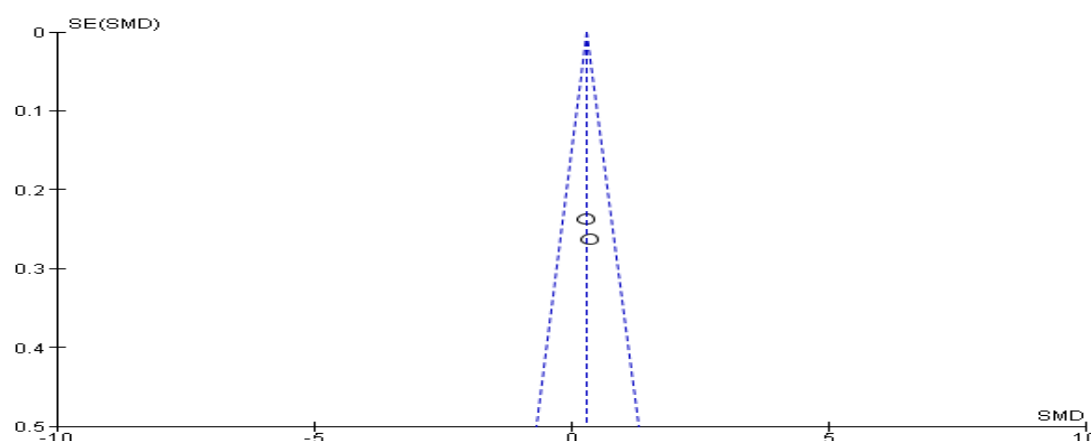


Fig 9: funnel plot showing absence of possible publication bias

D) Marginal bone loss (mm) at 3 months

Two studies^{23,25} containing data on 81 implants loaded, of which (n=43) implants were loaded early and (n=38) implants loaded immediately for MBL at 3 year. As shown in Figure 10, the SMD is -0.45 (-0.91 – 0.00) signifying that MBL at 3 months on an avg. was 0.45 mm less with immediate loading ($p=0.05$).

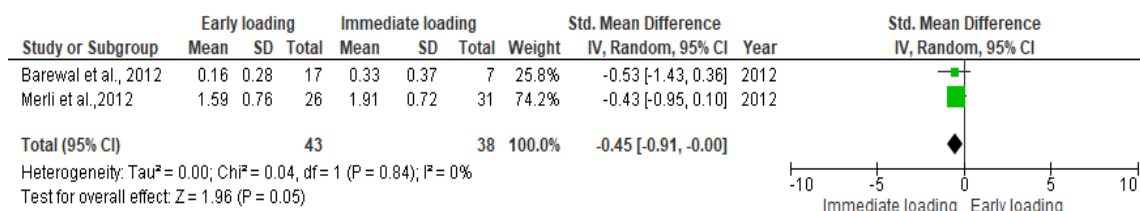


Fig 10: marginal bone loss at 3 years

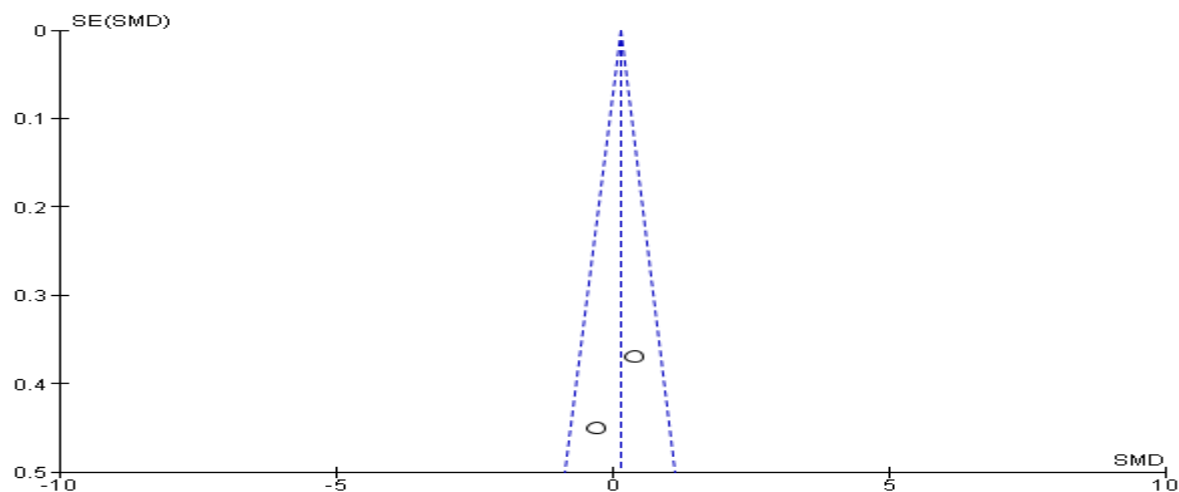


Fig 11: funnel plot showing absence of possible publication bias

E) Sensitivity Analysis

As shown, the pooled estimate signifies that the overall efficacy of immediate loading were superior compared to early loading with potentiality of no error in the overall estimate being less ($p > 0.05$) as shown in figure 12.

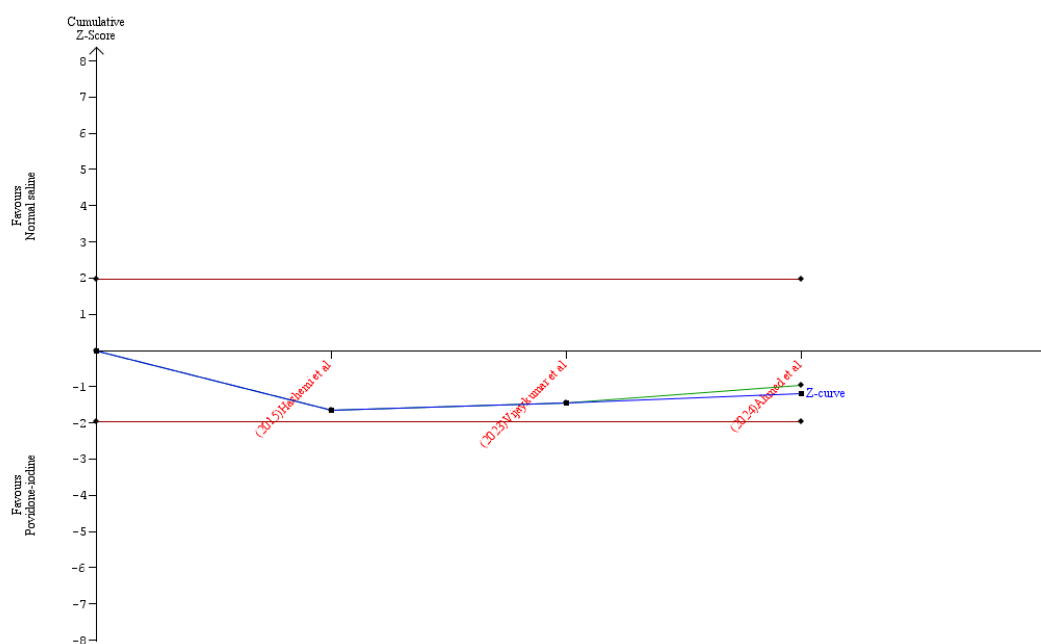


Figure 12: sensitivity analysis on overall effectiveness between ADMG and SCTG

IV. Discussion

Pigozzo et al., 2018²⁸ performed systematic review and meta-analysis to evaluate effectiveness of immediate loading protocol and early loading protocol for single dental implants. Databases were searched till May 2016 for retrospective studies, prospective studies and randomized controlled trials (RCTs) comparing immediate and early implant loading protocol and assessing outcome for survival rate and marginal bone loss (MBL).

Five studies were included for meta-analysis. It was found that there was no difference between two loading protocols at 1 year (Risk difference (RD): -0.00; 95% CI -0.04 – 0.04) and at 3 years ($p>0.05$) and for MBL at 1 year (mean difference (MD): 0.09; 95% CI -0.02 – 0.19, $p<0.05$) and at 3 year (MD: -0.23; 95% CI, -0.47 – 0.01, $p>0.05$). It was concluded that there was no difference between two loading protocols for survival rate and MBL.

Cosyn et al., 2019²⁹ performed systematic review with meta-analysis to compare between immediate implant placement (IIP) with delayed implant placement (DIP) for implant survival, surgical, aesthetic, clinical and radiographic outcomes. Databases were searched till May 2018 for randomized controlled trials (RCTs) and non-randomized controlled trials (NRSs) with comparing IIP with DIP with minimum follow up duration of 12 months. 3 RCTs and 5 NRSs with data from 233 IIP and 240 DIP with mean follow up duration of 12 – 96 months. Meta-analysis showed that survival rate of IIP was lower than DIP (Risk ratio (RR): 0.96; 95% CI 0.86 – 1.00) while clinical and aesthetic results were same for IIP and DIP. From the results of the studies, it was concluded that high risk of implant loss was seen for IIP than DIP.

Pommer et al., 2021³⁰ performed systematic review to assess whether the timing of implant placement (IP) in relation to tooth extraction (early IP, immediate IP and delayed IP) and the prosthetic implant loading (IL) time (early IL, immediate IL or delayed IL) affects the long-term treatment results with single-tooth implants. Databases were searched for comparative studies reporting on long-term results (survival rate and marginal bone resorption >3 years) of maxillary single-tooth implant placement. 7 controlled clinical trials (CCTs) were included for meta-analysis. IL was compared to DL in 3 studies on implant placement (IPIL vs IPDL, $p>0.05$), 2 studies on delayed placement (DPIL vs DPDL, $p>0.05$) while 2 studies compared early versus delayed placement with delayed loading ($p>0.05$). Data evaluated from 965 implants did not show any difference between placement timing and loading on bone remodelling. However, due to presence of insufficient data and heterogenous nature of data, no consensus on achieved on overall effectiveness between the two modalities.

Zhao et al., 2022³¹ performed systematic review to compare the clinical outcomes between immediate and non-immediate (early or delayed) loading in single-implant restorations. Databases were searched till January 2020 for randomized controlled trials (RCTs). 10 RCTs with data from 423 patients were included. There was no significant difference in outcomes between immediate and non-immediate loading cases: implant failure at patient level (Risk ratio (RR): 1.29; 95% CI 0.35 – 4.78, $p>0.05$) at implant level (RR: 1.19; 95% CI 0.40 – 3.51, $p>0.05$) and marginal bone loss (mean difference (MD): -0.04; 95% CI -0.16 – 0.08, $p>0.05$).

V. Conclusion

Immediate loading of single dental implants appears to be more effective and predictable as compared to early loading in terms of survival rate and marginal bone stability. Our study confirms, immediate loading can be considered a reliable alternative to early loading, offering the advantage of reduced treatment time without compromising outcomes. However, furthermore RCTs with larger follow up duration and sample size should be conducted to findings the results of the study.

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