

Survival and Marginal Bone Loss in Immediate Post-Extraction Implants versus Delayed Implants: A Systematic Review and Meta-Analysis

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Abstract: There are a series of protocols regarding the placement of dental implants after tooth extraction. The advantages and disadvantages that determine the procedure and timing of each dental implant placement process are key to achieving success. The main objective of this study was to elucidate/establish/determine whether there are differences in the survival and marginal bone loss between implants placed immediately after placement and those placed following a delayed protocol. A search was conducted in Pubmed, BVS, and Cochrane. Eleven randomized clinical trials that fulfilled the inclusion criteria were selected, and a meta-analysis was carried out to compare the implant failures and marginal bone loss between study groups. The analysis showed that delayed implant placement had fewer failures (odds ratio, fixed effects: 3.47 [CI: 95% (1.17, 10.48)]). As regards marginal bone loss, there was a tendency towards less tissue loss in the delayed placement group (mean difference, random effects: 0.11 [CI: 95% (−0.10, 0.33)]); however, further research is needed to evaluate this variable.

Keywords: dental implants; single tooth; dental extraction; alveolar bone loss; systematic review



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1. Introduction

Although the phenomenon of titanium binding to bone had already been described by other researchers [1–3], it was in 1982 when dentist George Zarb organized the Toronto Conference, in which Brånemark presented the bone–titanium bonding process. It was during this conference that the term “osseointegration” was used for the first time, thus marking the beginning of modern implantology [2,4].

At the 3rd ITI Consensus Conference held in 2003 [5], a classification was established as to the times involved in the placement of dental implants after tooth extraction. This classification system was based on the clinical outcome of physiological wound healing. Four different types were defined: type 1: Immediate placement on the day of tooth extraction in the same surgical procedure; type 2: Implant placement after soft tissue healing, but without clinically significant bone healing. Taking between 4 and 8 weeks is type 3 with implant placement after clinically and/or radiographically significant bone filling of the alveolus. A healing period of 12 to 16 weeks is type 4, with the placement of the implant in a completely healed site. Complete bone healing requires 16 weeks or more.

In 1986, Albrektsson and Zarb established the following conditions as success criteria for implants: absence of mobility, pain, infection, peri-implant radiolucidity, and marginal bone loss of less than 1.5 mm during the first year after prosthetic abutment connection, followed by 0.2 mm per year [6].

After tooth extraction, resorption of up to 50% of the original width of the alveolar ridge should be expected in the first year; bone resorption is greater in the vestibular bone than in the lingual/palatine, and a reduction in alveolar bone is greater in the posterior regions of the dental arches [7]. Most forms of vertical bone loss occur 3 months after

extraction. Similarly, at 6 months, a horizontal bone loss of 29–63% and vertical marginal bone loss of 11–22% are expected. This bone loss is related to negative situations in terms of aesthetics or the inability to apply the dental implant, and thus, requires guided bone regeneration techniques [8]. The immediate placement of the dental implant can also reduce the resorption of post-extraction alveoli [8,9].

Table 1 shows the advantages and disadvantages of the different placement times of dental implants [5].

Table 1. Advantages and disadvantages according to the type of implant placement taken from Hämmerle et al. [5].

Classification	Advantages	Disadvantages
Type 1	Fewer interventions. Shorter time. Optimal availability of existing bone.	Placement and anchoring are dependent on the morphology of the receiving site. Fine gum biotype hinders optimal outcome. Potential lack of keratinized mucosa for flap adaptation. Possibility of complementary surgical processes. Sensitive to technique.
Type 2	The increase in soft tissue dimension facilitates flap handling. The resolution of local pathology can be evaluated.	Placement and anchoring are dependent on the morphology of the receiving site. More time required. The walls of the alveolus exhibit varying amounts of resorption. Possibility of complementary surgical processes. Sensitive to technique.
Type 3	The substantial bone filling of the socket facilitates implant placement. Greater ease of handling the flap.	More time is required. Possibility of complementary surgical processes. The walls of the alveolus exhibit varying amounts of resorption.
Type 4	Clinically cured bone tissue. Greater ease of handling the flap.	More time is required than types 1, 2, and 3. Possibility of complementary surgical processes. Large variation in bone volume.

The concept of success differs from the term “survival” in some regards, so in order to evaluate the performance of an implant nowadays, it is more appropriate to refer to its success, which could be summarized as the absence of biological, aesthetic, and technical complications, according to Blanco et al. [10].

The present research focuses on the examination of the number of failures and the amount of marginal bone loss detected in the study groups analyzed, including those with immediate implants and delayed implants.

The main objective of this study was to determine if there are differences in terms of survival and marginal bone loss, MBL, for implants placed immediately versus those placed using a conventional or delayed protocol.

The secondary objectives were to compare the aesthetic results achieved in implants placed immediately versus those that were conventional/delayed; to analyze patient satisfaction with immediate implant placement or with the conventional process; and to identify indications for adopting one method or another depending on which of them is the most convenient for the patient.

2. Materials and Methods

2.1. Protocol

The following PICO “Patients, Intervention, Comparison and Outcome” question was asked: Are there differences between survival and marginal bone loss (outcome) of

immediately placed dental implants versus implants placed in a delayed or conventional way (comparison) in patients (patients) requiring dental implant placement (intervention)?

For the writing of this paper, the PRISMA guidelines were followed [11].

2.2. Eligibility Criteria

The inclusion and exclusion criteria for the studies were designed to ensure that the research was focused, relevant, and of high quality.

Studies on patients over 18 years old and randomized trials were included. The rehabilitation presented in the studies had to be unitary, both in the mandible and in the upper jaw, without considering the location, aesthetic, or posterior sector. The immediate loading of exclusively non-functional implants was allowed in the immediate implant group. Bone regeneration in the group of conventional or delayed implants was not included; however, it was included as an option for the group of immediate implants. Alveolar preservation was allowed in the delayed group. Finally, all the selected articles had to compare both groups of implants, with immediate and delayed placement, in the same subject or in different subjects. There were no restrictions related to language or the year of publication of the article.

Ensuring patients were aged over 18 to comprise an adult study population allowed for the fact that adults may have different healing processes and responses to treatment compared to children or adolescents. Randomization reduces bias and ensures that the results are more likely to be attributable to the intervention rather than other factors. Comparative studies ensure that the research provides direct comparisons between immediate and delayed implant placements, which is crucial for understanding the relative merits of each approach. Focusing on single-unit restorations allows for a more controlled assessment of outcomes, as multi-unit or full-arch rehabilitations introduce more variables. Non-functional immediate loading allows the study of the biological response to implants without the confounding factor of functional load, which could affect osseointegration. Including immediate implants with bone regeneration recognizes the clinical reality that some immediate implants may require bone augmentation and alveolar preservation, which reflects a common clinical practice in delayed implant placement, providing a relevant comparison to immediate placement.

No case reports, case series, or observational studies were included as these types of studies often lack the rigorous control of experimental studies and may introduce bias, making them less reliable. Studies referring exclusively to fully edentulous patients and those requiring rehabilitation of more than one implant were discarded because these studies often involve more complex and variable treatment protocols, which could confound the results. Functional immediate loading was not accepted because the inclusion of functional loading could confound the results by introducing additional variables such as occlusal forces, which may affect implant success.

By adhering to these criteria, the studies aim to provide clear, reliable data on the specific outcomes of interest, minimizing confounding factors and enhancing the applicability of the results to clinical practice. The criteria also help to ensure that the studies are comparable, which is essential for meta-analysis and systematic reviews.

2.3. Sources of Information and Search

A literature search was carried out in PubMed Medline, BVS Virtual Health Library, and Cochrane using the following keywords: “Dental implants AND immediate placement OR immediate dental implants OR fresh extraction socket OR post-extractive implants” for the first search, which were common in all databases used. A second search was performed with the keywords: “Immediate dental implant placement AND delayed dental implant placement” in the PubMed database. Both searches were filtered by study type to collect only randomized clinical trials, RCT. There was no time limitation. Figure 1 shows the flowchart followed in the search and selection of studies.

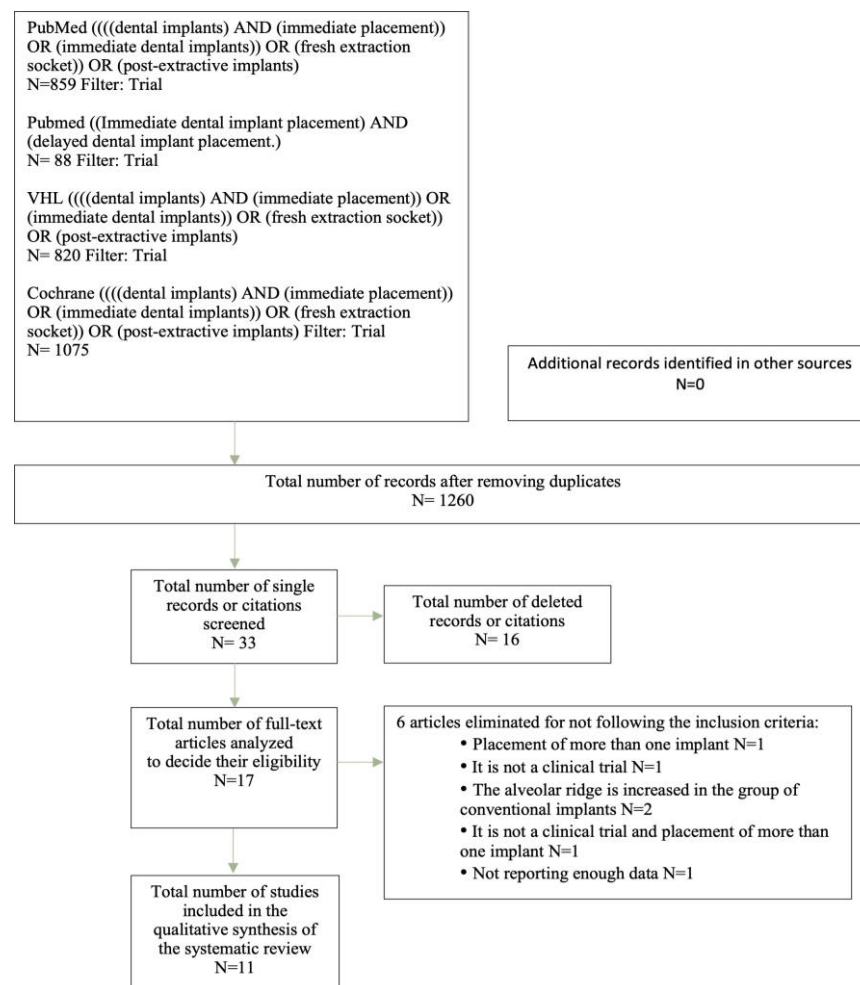


Figure 1. Flow diagram of information through the different phases of a systematic review [11].

2.4. Selection of Studies

The first phase of the search focused on the selection of clinical trials by title and abstract, excluding all those that did not fulfill the inclusion criteria, followed by a second and final phase in which the articles that met them were read completely and exhaustively. After the review of each article by two independent investigators (A.P-S and B.P-P), the studies that met the inclusion criteria were selected.

2.5. Data Collection Process and Data List

Data related to the author, year of publication, and type of study were collected. For the quantitative analysis, the total number of patients who presented and volunteered for each study was incorporated, as well as the initial and final number of subjects and the totality of implants placed, further divided into immediate implants and conventional or delayed implants. Follow-up time, the success rate of both groups of implants, and the number of failures were also added. Regarding bone tissue, marginal bone loss, MBL, with standard deviation, was included. Insertion torque Ncm and RFA data were also included with standard deviation for immediate and conventional implants.

In terms of the qualitative analysis, attention was paid to five main variables: whether bone graft was performed, and the type of graft used, whether alveolar preservation was made in the group of conventional or delayed implants, whether a membrane was used during the surgical process, whether immediate non-functional loading was performed, and whether the stability of the implant was measured.

2.6. Risk of Bias in Each Article and between Studies

The risk of bias for each study was analyzed using the Cochrane tool for assessing the risk of bias in randomized clinical trials [12]. This bias assessment system consists of six domains: random sequence generation, allocation concealment, blinding of patients, operators, and assessors, incomplete results, selective outcome communication, and other biases. The overall risk of bias between studies was assessed.

2.7. Synthesis of Results

The meta-analysis was performed with the RevMan 5 program (Review Manager [RevMan] [Computer program]. Version 5.4. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). The odds ratio OR for dichotomous variables was analyzed, as well as early implant failure, and the mean difference MD with standard deviations SDs for continuous variables as marginal bone loss were analyzed with a 95% confidence interval CI. Differences were established by $p < 0.05$.

Heterogeneity was estimated by forest-plot inspection and the estimation of I^2 and Chi-square analysis [12].

2.8. Publication Bias

To analyze the publication bias, the funnel-plot diagram was performed.

2.9. Quality of the Evidence

The quality of the evidence was assessed using the GRADE rating system [13]. For this, GRADEpro 3.2 software was used, assigning studies an adequate level of evidence [14].

2.10. Additional Analysis

Sensitivity analysis was performed.

3. Results

3.1. Selection of Studies

For the first search, a total of 2754 articles were collected from the three platforms used. These, together with the articles resulting from the second search, gave a total of 2842 studies. After the elimination of duplicates, 1260 articles were obtained, out of which 33 were selected, taking into account their titles and abstracts. Those that did not meet the criteria were excluded, resulting in 17 articles that were scrutinized in depth. Out of these, six studies were eliminated given that they did not follow some of the established inclusion criteria: in one of them [15], more than one consecutive implant was placed; in two [16,17] the clinical trials were not randomized; in another two [18,19] alveolar ridge augmentation was performed in the group of conventional implants; and, finally, in another study [20], the number of implant failures was not studied, nor was marginal bone loss measured in each study group (Figure 1). Thus, 11 articles were included in the final qualitative synthesis [19,21–30].

3.2. Study Characteristics

All of the included papers studied human patients of both sexes older than 18 years, and they compared two study groups as follows: immediate implant group versus conventional or delayed implant group, and they did not perform immediate functional loads in any study group. Only 3 articles immediately loaded the implants in a non-functional manner [21,28,30]. Follow-up time ranged from 430 to 60 months [19]. Sample sizes also varied according to the study, ranging from 2425 to 12,423 patients, resulting in a total of 661 patients: 333 patients received an immediate implant, and 328 patients received a delayed implant. Table 2 shows the characteristics of the included studies.

A detailed analysis of the potential biases present in the included works was carried out [12].

Table 2. Sample size, follow-up time, and number of implants placed.

Author and Year	N Patients Home	N Final Patients	Follow-Up Time [Months]	N Total Implants	N IOII	N IOID
Covani et al. 2004 [22]	33	33	12	35	20	15
Salimon Ribeiro et al. 2008 [21]	64	64	18–36	82	46	36
Felice et al. 2011 [30]	106	106	4	106	54	52
Felice et al. 2015 [28]	50	48	12	50	25	25
Ebenezer et al. 2015 [24]	30	30	6	33	NS	NS
Malchiodi et al. 2016 [26]	40	40	12	40	20	20
Checchi et al. 2017 [29]	100	91	12	100	50	50
Tonetti et al. 2017 [23]	124	115	36	124	62	62
Kamel et al. 2018 [25]	24	24	6	24	12	12
Amin et al. 2019 [27]	50	50	6	50	25	25
Slagter et al. 2021 [19]	40	35	60	40	20	20
Total	661	636		684	334	317

IOIIs: Immediate osseointegrated implants; IOIDs: Deferred osseointegrated implants; NS: Not specified.

3.3. Risk of Bias in Studies

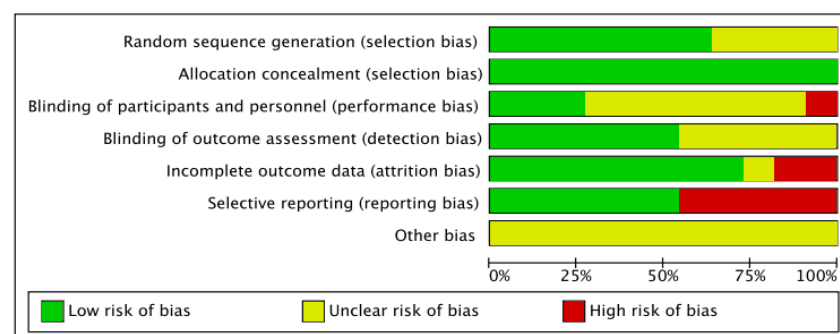
Selection bias in terms of randomization sequence generation was low, as randomized clinical trials were selected. It was considered unclear selection bias when the randomization system that had been used for the selection of the sample was not specified [21,22,24,27]. The study by Slagter et al. [19] did not specify the randomization system that was carried out, but it was labeled as low risk of bias because its title included the words “randomized controlled trial”.

The selection bias regarding the concealment of the randomization sequence was identified as high if patients were changed from the experimental group (immediate implants) to the control group (delayed implants). An unclear type of bias was considered when it was not specified whether there were changes between patient groups, and a low-risk bias was when there was no change between study groups. All 11 studies were at low risk of bias in terms of concealment of the randomization sequence.

Performance accuracy in terms of blinding participants and personnel and detection bias in terms of blinding outcome observers/examiners was unclear when the study did not specify whether the surgeon who placed the implants or the assessor of the study parameters was blinded [19,22–25,27,30]. If the staff were blinded, it was taken as a low risk of bias [26,28,29]. Three studies [23,25,30] specified that outcome assessors were blinded and deemed low risk, but those studies that did not indicate whether operators were blinded were deemed unclear risk.

Attrition bias was low as only three studies lost participants [19,23,29]. Regarding the selective reporting bias, it was considered high in studies in which data on marginal bone loss were not reported [21,23–25,30].

Figures 2 and 3 show the graph and summary of the risk of bias for the studies comparing immediate placement implants and delayed or conventional placement implants.

**Figure 2.** Risk of bias graph for comparative studies of immediate implants vs. delayed implants.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Amin et al 2019	?	+	?	?	+	+	?
Checchi et al 2017	+	+	+	+	?	+	?
Covani et al 2004	?	+	?	?	+	+	?
Ebenezer et al 2015	?	+	?	?	+	-	?
Felice et al 2011	+	+	?	+	+	-	?
Felice et al 2015	+	+	+	+	+	+	?
Kamel et al 2018	+	+	?	+	+	-	?
Malchiodi et al 2016	+	+	+	+	+	+	?
Ribeiro et al 2008	?	+	-	?	+	-	?
Slagter et al 2021	+	+	?	?	-	+	?
Tonetti et al 2017	+	+	?	+	-	-	?

Figure 3. Summary of risk of bias for comparative studies of immediate implants vs. delayed implants [19,21–30].

3.4. Results of Individual Studies

3.4.1. Success Rate of Implants Placed

Data on both the success rate and failures of the implants placed were extracted to know which group had greater deficiencies. As can be seen in Table 3, there were no differences between success rates. The success rate was matched with 100% success in both groups in five clinical trials [19,22,25–28]. Regarding the number of implant failures, there were five studies [21,23,28–30] with a higher number of failures in the immediate implant group, and one study [24] reported four failures in the delayed implant group versus one case in the immediate implant group.

Table 3. Implant success rate and failures.

Author and Year	N Total Implants	N Failures II	N Failures ID	Success Rate II [%]	Success Rate ID [%]
Covani et al. 2004 [22]	35	0	0	100	100
Salimon Ribeiro et al. 2008 [21]	82	3	0	93.5	100
Felice et al. 2011 [30]	106	2	0	96	100
Felice et al. 2015 [28]	50	2	0	92	100

Table 3. *Cont.*

Author and Year	N Total Implants	N Failures II	N Failures ID	Success Rate II [%]	Success Rate ID [%]
Ebenezer et al. 2015 [24]	33	1	4	NS	NS
Malchiodi et al. 2016 [26]	40	0	0	100	100
Checchi et al. 2017 [29]	100	5	2	89.4	95.4
Tonetti et al. 2017 [23]	124	1	0	98.4	100
Kamel et al. 2018 [25]	24	0	0	100	100
Amin et al. 2019 [27]	50	0	0	100	100
Slagter et al. 2021 [19]	40	0	0	100	100
Total	730				

IDs: deferred implants; IIs: immediate implants; N: number; and NS: not specified.

3.4.2. Marginal Bone Loss (MBL)

Data on marginal bone loss can be seen in Table 4. Four studies [19,25,26,29] registered a higher MBL in the group of immediate implants; this difference was significant in only one paper [29]. One study [28] recorded greater marginal bone loss in the delayed implant group, and the remaining six [21–24,27,30] did not perform MBL measurements. Three studies [26,28,29] used parallelized periapical radiographs; a blinded assessor was used in two of them [28,29], and one study [19] used CBCT to perform bone measurements.

Table 4. Bone loss by group.

Author and Year	IBL [mm]	SD [mm]	DBL [mm]	SD [mm]	Observation Time [Months]	Measurement Technique
Felice et al. 2015 [28]	0.13	0.09	0.19	0.10	12	Blinded outcome evaluator on parallelized periapical radiographs
Malchiodi et al. 2016 [26]	0.68	0.43	0.4	0.26	12	Parallelized periapical radiography
Checchi et al. 2017 [29]	1.06 *	0	0.63*	0	12	Blinded outcome evaluator on parallelized periapical radiographs
Slagter et al. 2021 [19]	0.71	0.35	0.54	0.41	60	CBCT

SD, standard deviation; DBL: deferred bone loss; IBL: immediate bone loss; and [*]: significant difference.

Kamel et al. [25] performed measures on marginal bone loss but did not specify the data for each study group, only capturing the values of statistical mean differences.

3.4.3. Bone Graft Placement and Alveolar Preservation

Nine studies [19,23–30] performed bone grafting in the immediate implants group, and two studies used membranes [23,25]. In seven studies [19,23,25,27–30], preservation of the alveolar ridge was performed (Table 5).

Table 5. Types of bone grafting, use of membranes, and alveolar preservation. Stability of implants placed.

Author and Year	Bone Fracting in Immediate Implants [Yes/No]	Type of Bone Graft in Immediate Implants	Membrane Use [Yes/No]	Preservation of the Delayed Alveolar Ridge [Yes/No]
Covani et al. 2004 [22]	No	No	No	NS
Ribeiro et al. 2008 [21]	No	No	No	No
Felice et al. 2011 [30]	Yes	Bio-Oss®	No	Yes
Felice et al. 2015 [28]	Yes	NS	No	Yes

Table 5. Cont.

Author and Year	Bone Fracting in Immediate Implants [Yes/No]	Type of Bone Graft in Immediate Implants	Membrane Use [Yes/No]	Preservation of the Delayed Alveolar Ridge [Yes/No]
Ebenezer et al. 2015 [24]	Yes	NS	No	NS
Malchiodi et al. 2016 [26]	Yes	Bio-Oss®	No	No
Checchi et al. 2017 [29]	Yes	Gen-Os®	No	Yes
Tonetti et al. 2017 [23]	Yes	Bio-Oss®	Yes	Yes
Kamel et al. 2018 [25]	Yes	Heterologous graft	Yes	Yes
Amin et al. 2019 [27]	Yes	NS	No	Yes
Slagter et al. 2021 [19]	Yes	Autologous graft from the tuberosity	No	Yes

Bio-Oss® (Geistlich Pharma, Lucerne, Switzerland); Gen-Os (Osteobiol, Tecnos, Giaveno, Italy); and NS: not specified.

Four studies indicated the mean values of the insertion torque of the implants placed in both groups, which were the same for both groups of immediate implants and delayed implants; three studies had the following values: 40 Ncm [21] and 35 Ncm [28,30]. In the clinical trial of Malchiodi et al. [26], the mean value of the insertion torque differed between the groups of immediate and delayed implants (46 ± 9.9 and 52 ± 9.23 Ncm, respectively). In addition, this was the only paper [26] in which the stability coefficient of the implant placed (ISQ) was measured by Osstell® (Gothenburg, Sweden), which was higher in the group of delayed implants (66.00 ± 8.25) if compared to the group of immediate implants (61.90 ± 9.99) (Table 6). The rest of the studies [19,22–25,27,29] did not provide data stability.

Table 6. Insertion torque and stability coefficient of the implants at the time of insertion.

Author and Year	Insertion Torque in Ii [ncm]	Sd	Insertion Torque in Di [ncm]	Sd	ISQ II	Sd	ISQ DI	Sd
Salimon Ribeiro et al. 2008 [21]	40	NS	40	NS	NS	NS	NS	NS
Felice et al. 2011 [30]	35	NS	35	NS	NS	NS	NS	NS
Felice et al. 2015 [28]	35	NS	35	NS	NS	NS	NS	NS
Malchiodi et al. 2016 [26]	46	9.9	52	9.23	61.9	9.99	66.00	8.25

DIs: deferred implants; IIs: immediate implants; ISQ: coefficient of stability of the implant placed; and NS: not specified.

3.4.4. Immediate Non-Functional Loading

Out of the 11 studies analyzed, 3 [21,28,30] performed immediate non-functional or non-occluded loading. The rest of the studies [19,22–27,29] did not perform immediate loading; they loaded the implants following a delayed protocol.

3.5. Synthesis of Results

3.5.1. Meta-Analysis of Implant Failures

Eleven studies [19,21–30] were included in the meta-analysis on implant failures in both groups, but only 5 studies [21,23,28–30] were finally analyzed because those studies that had 0 failures in both groups were dismissed. The study by Ebenezer et al. [24] was not taken into consideration, as they did not indicate the number of implants placed in each group.

The heterogeneity was considered null on account of the following values: ($\text{Chi}^2 = 0.45$ $P = 0.98$) $I^2 = 0\%$. For this reason, a fixed-effect model was utilized.

The forest plot (Figure 4) indicated that there were no significant differences between the five studies analyzed since the 95% confidence intervals overlapped. All studies crossed the no-effect line, indicating that there were no significant differences in the number of early failures between study groups within each study.

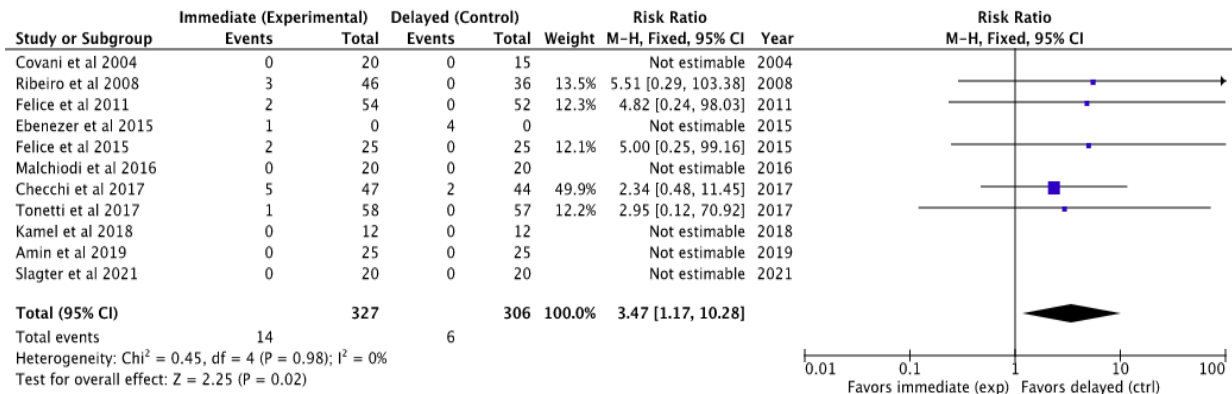


Figure 4. Meta-analysis of implant failures (immediate vs. delayed) [19,21–30].

The diamond is on the right side of the no-effect line (fixed effects, odds ratio: 3.47 [CI: 95% (1.17, 10.48)]), which suggests that, in a weighted manner, there were fewer early failures in the group of delayed implants.

3.5.2. Meta-Analysis of Marginal Bone Loss (MBL)

Initially, four studies [19,26,28,29] were included for meta-analysis. Sensitivity analysis showed that, by excluding the work of Felice et al. [28], I^2 was reduced considerably from 87% to 0% (95% CI). We, therefore, considered excluding it; however, as the study by Checchi et al. [29] was not taken into account by the program because it did not provide standard deviation values, the decision was made to use a random-effects model and to maintain the study by Felice et al. [28]. The random-effects model assumes that differences between studies are due to high heterogeneity rather than chance.

The forest-plot study (Figure 5) indicated that there were no significant differences between two of the included studies [19,26], since 95% of the confidence intervals overlapped; in these two cases, delayed implants were favored, while in the study by Felice et al. [28] the data favored immediate implants.

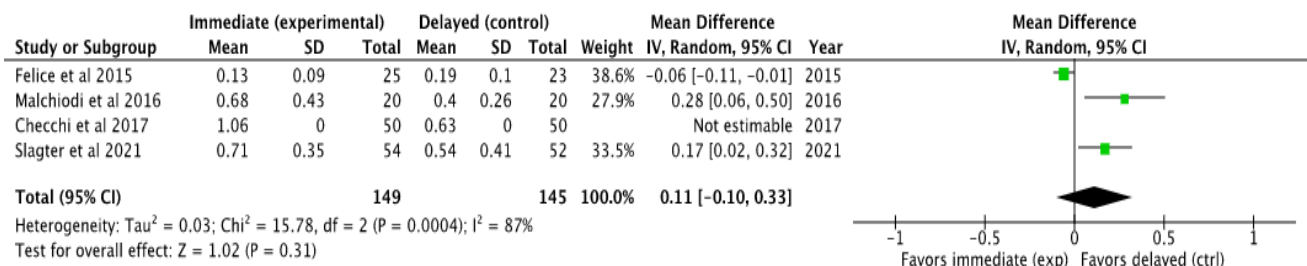


Figure 5. Meta-analysis of marginal bone loss MBL (immediate vs. delayed implants) [19,26,28,29].

Although the study by Checchi et al. [29] was not estimated in the meta-analysis, the individual results of this study favored the group of delayed implants due to reduced bone loss.

The diamond tends to orient itself towards the right side but crosses the line of no effect (mean difference, random effects: 0.11 [CI: 95% (-0.10, 0.33)]), thus tending to favor the group of delayed implants. That is, less marginal bone thickness was lost in the groups that were treated with conventionally placed implants.

3.6. Additional Analysis

Sensitivity Analysis

A sensitivity study of both parts of the meta-analysis was performed, showing changes in the results for the section on marginal bone loss. To carry out this sensitivity study, a continuous pattern of exclusion was followed; that is, the studies were eliminated one by one to identify which study or studies triggered the value of heterogeneity. The meta-analysis of marginal bone loss showed that the study by Felice et al. [28] was responsible for the exaggerated increase in heterogeneity (I^2) since its exclusion led to a decrease in heterogeneity from 87% to 0%.

4. Discussion

The 11 selected clinical trials were examined for each comparative group and the success rate and/or the number of implant failures. Marginal bone loss was not detected in all studies. Two trials [22,27] performed measurements of bone loss in the bucco-lingual aspect, and another two studies [23,25] performed the relevant assessments but did not specify the data necessary for inclusion in the meta-analysis.

4.1. Study Design and Risk of Bias

The 11 studies selected varied in their outcome of risk of bias, which was high for 6 of them [19,21,23–25,30], low for 2 [26,28], and unclear for 3 [22,27,29], so fewer studies were well-designed. The high risk and/or unclear risk of bias was concentrated in the loss of patients, incomplete outcome data, and attrition bias [19,23]; in the non-blinding of surgeons and observers in both groups [19,21,22,24,27], the blinding of participants and personnel/blinding of outcome assessments, performance bias/detection bias, and also selective reporting biases were analyzed [21,23–25,30]. It is very important to consider the factor of performing the correct blinding of the operators since a lack of surgeon blinding can lead to variations in the technique of placement of the implants. Similarly, the blinding of the examiners prevents influences on the assessment of marginal bone loss and other peri-implant parameters. Regarding the selective communication of the results, five studies [21,23–25,30] were considered at high risk of bias since they did not report data on marginal bone loss, which is an essential factor to evaluate the success of a dental implant according to the success criteria of Albrektsson et al. [9]. The studies [22,27] that performed bone measurements horizontally were also attributed a low risk of bias as they considered a bone parameter but were not included in the meta-analysis, similar to those studies at high risk of bias because they did not expose the required data. The study by Ebenezer et al. [24] did not report data for any type of variable and was the most deficient trial of all. It should be noted that in most studies, the authors omit information regarding the concealment of the randomization sequence, but in this work, this has been evaluated as a low risk of bias, considering that all studies have been published as randomized clinical trials.

4.2. Evaluation of Implant Success Rate and Number of Failures

The success rate of dental implants was measured following the criteria posed by Albrektsson et al. [5] in most studies analyzed.

In 2007, at the International Congress of Oral Implantologists Consensus Conference, Italy, Pisa, ICOI31, the degree of health of osseointegrated implants was updated and simplified based on success, survival, and implant failure. The success of the implant combines the following clinical conditions: absence of pain or sensitivity in function, lack of mobility, radiographic bone loss less than 2 mm from the first surgery, and absence of purulent exudates. On the other hand, we have the concept of survival, which harbors differences with respect to success and has two possible outcomes: satisfactory and committed, with slight clinical variations between them [31].

Satisfactory survival has three points in common with success: absence of pain or sensitivity in function, lack of mobility, and exudates, so the only difference between both concepts is the range of radiographic bone loss, which exceeds 2 mm, reaching a maximum

of 4 mm. The term committed survival has more divergences with respect to the previous two since they only share the absence of mobility. The rest of the clinical conditions accept the possibility of success as follows: sensitivity in function; radiographic bone loss of less than 4 mm or less than half of the implant; probing depth of less than 7 mm, and the option of a history of exudates [31]. Implant failures would occur in any of these situations: pain in function, mobility, radiographic bone loss of half the length of the implant, uncontrolled exudate, and non-existence in the mouth [31].

According to Misch et al. [31], the term “success” should include a minimum period of 12 months. This author classified success in three ways: early, referring to the success of the implant if it is in a time interval of 1 to 3 years; intermediate, for implants that exist in the mouth for between 3 and 7 years; and, finally, long-term success, which is quantified from 7 years of life in the mouth.

Regarding the articles included in this study, Ribero et al. [21] and Malchiodi et al. [26] defined the success criteria based on the principles of Albrektsson et al. [5]. Checchi et al. [29] indicated three essential conditions for the success of dental implants: absence of mobility, absence of progressive infection of the marginal bone, and absence of any mechanical complications that could make the use of the implant impossible.

As previously mentioned, 10 clinical trials captured the success rate of implants; in 5 of them, the immediate implant group achieved 100% [19,22,25–27] compared to the delayed implant groups, which achieved 100% success in eight different studies [19,21–23,25,26,28,30].

The study by Felice et al. [30] did not specify the number of implants placed in each group but indicated that 4% of immediate implants failed, which led to an understanding that the success rate was 96%.

On the other hand, the group of delayed implants registered the lowest value of success rate out of the 11 analyzed in the study by Checchi et al. [29], which was 95.4% (2/23).

In five studies [19,22,25–27], there were no implant failures in either group. Studies that failed had the highest values in the immediate implant group compared to the delayed implant group, except for the study by Ebenezer et al. [24] which exceeded this amount in the opposite way (4 vs. 1) but did not indicate the number of implants placed in each study arm and was not considered in the meta-analysis, so their data did not have an impact on the result (Table 5).

Considering these outcomes, it can be claimed that the group of delayed implants had higher values in terms of survival and, therefore, fewer early failures. The lowest value of implant survival (89.4%) was obtained in the group of immediate implants, and if all failures were quantified, the total sum of the group of immediate implants [14] exceeded the total sum of the group of delayed implants (9), with a difference of 8 failures, favoring the control group (of delayed implants).

In view of the above, it can be confirmed that the meta-analysis favors the delayed implantation protocol since there are fewer early failures in the delayed implant groups if compared to the immediate implant groups in the case of a significant difference (odds ratio, fixed effects: 3.47 [CI: 95% (1.17, 10.48)]) (Figure 4).

4.3. Assessment of Marginal Bone Loss (MBL)

Marginal bone levels can be initially measured during the first surgical procedure from the crestal position of the implant. Subsequent marginal bone loss is determined at post-implant osseointegration through radiographic evaluation [31].

Given that traditional radiographs are limited to assessing mesial and distal dimensions, computer-aided radiographic imaging and personalized X-ray positioning devices are recognized as superior methods for evaluating marginal bone loss [31].

A comparative analysis of marginal bone loss across various implant study groups was conducted in five of the included studies [19,25,26,28,29]. Data from these studies indicate that Slagter et al. and Kamel et al. [19,25] used Cone Beam Computed Tomography (CBCT) for their measurements, whereas Malchiodi et al., Checchi et al., and Felice et al. [26,28,29] employed standardized, parallelized, and calibrated radiographs. However, the study by

Kamel et al. [25] was excluded from the bone loss meta-analysis due to the reported data reaching a statistical mean difference ($0.33 \text{ mm} \pm 0.30 \text{ mm}$) in favor of the delayed implant group without specific details on bone tissue loss for each group.

In one study [28], the immediate implants group exhibited a lower value of marginal bone loss over a 12-month observation period.

Conversely, the remaining two studies [19,26] reported lower marginal bone loss values for the delayed implants group. This suggests that delaying implant placement until after a period of bone healing (3 months) is conducive to reducing hard tissue loss, which significantly contributes to the success of the treatment and patient satisfaction.

The trend supports the conventional or delayed implantation protocol as a means to minimize marginal bone loss (mean difference, random effects: 0.11 [CI: 95% ($-0.10, 0.33$)]), as depicted in Figure 5. However, these findings should be approached with caution due to the limited number of studies included in the meta-analysis.

None of the authors of the published papers included in this study measured/mentioned bone loss (physiological bone atrophy) from the time of tooth extraction until implantation in the newly formed bone in the late loading protocol. Although the results of MBL are in favor of the delayed implant-loading protocol, for the MBL results to be relevant, bone loss in the period after tooth extraction should also be taken into consideration, which could probably shed a different light on this problem.

4.4. Use of Bone Grafts and Preservation of the Alveolar Ridge

4.4.1. Bone Grafts

Nine studies [19,23–30] placed a bone graft accompanying immediate implants. Four of these studies did not have any implant failure, with a 100% success rate in the immediate implant group. It should be noted, though, that graft failure, whatever the cause, leads directly to early implant failure since osseointegration at the coronal level would not be complete even if there was apically endosseous integration [32].

In summary, the two types of graft that surgeons used were autologous or autogenous [19,26], considering the gold standard [33] since they meet the three key characteristics of grafts, osteogenesis, osteo-induction and osteo-conduction, and prevent the transmission of diseases and immune rejection [34]. On the other hand, heterologous grafts or xenografts only have osteo-conductive properties [23,25,29,30].

4.4.2. Alveolar Preservation

Alveolar preservation is aimed at maintaining the volume of the ridge that exists at the time of tooth extraction for, in this case, delayed implantation [33]. The dimensional changes that occur after tooth extraction have been exhaustively investigated. It has been shown that the alveolar crest undergoes volumetric changes in the first 2–3 months, which are more pronounced in the vestibular cortical [35,36]. To prevent the bony ridge from deforming and preserving the bucco-lingual and mesio-distal dimensions after the extraction of the tooth, techniques that prevent the collapse of bone tissue are chosen, as is the case of alveolar preservation techniques [33]. Seven clinical trials carried out this technique [19,23,25,27–30] in the delayed implant group but did not provide data on the degree of preservation achieved when performing it.

4.5. Patient Satisfaction

The subjective opinion of the patient with the treatment is crucial to achieving complete success of the procedure. The patient must be comfortable and satisfied with what has been established, so this was set as the secondary objective of this work.

The functional and aesthetic results of implant rehabilitations were evaluated in clinical studies based on patient questionnaires to compare the procedures carried out to replace the missing tooth [20]. Of the 11 clinical trials of this study, 5 [19,23,28–30] commented on patient satisfaction, 2 used a visual analog scale (VAS) [19,23], and the other 3 separated partial and total satisfaction between groups, allowing patients to be quantified

by including them in each category [28–30]. The results obtained did not show significant differences between the two study groups.

4.6. Stability of Implants Placed

Of the 11 clinical trials included in this study, only four gave information on the stability of the implants placed [21,26,28,30]. Two studies [28,30] accommodated motors with an insertion value of more than 35 Ncm. Those implants that achieved this insertion torque were loaded in an immediate non-functional way, and in those that did not achieve the insertion of torque, a conventional load was carried out after 4 months. Ribeiro et al. [21] proposed a minimum torque of 40 Ncm for the insertion of implants from the immediate implant and delayed implant groups in such a way that those registering a torque of at least 40 Ncm were immediately loaded in a non-functional manner. Finally, Malchiodi et al. [26] were the only ones that measured stability in two ways: on the one hand, they took into account the insertion of the torque for each implant placed in both groups of immediate and delayed, allowing increments of 5 Ncm, from 15 Ncm to 70 Ncm, as the maximum torque; as such, 40 implants, 26 of which included 15 immediate and 11 delayed implants, obtained an insertion torque of 35–50 Ncm; 9 implants, 4 immediate and 5 deferred had insertion torques of 51–60 Ncm; and 5 implants, 1 immediate and 4 deferred had insertion torques of 61–70 Ncm. The mean values of the insertion torques per group were 46 ± 9.95 Ncm for the immediate implant group and 52 ± 9.23 for the delayed implant group. On the other hand, they measured the RFA using Osstell®. RFA values were 61.90 ± 9.99 for immediate implants and 66 ± 8.25 for delayed implants. Of the 40 implants placed, 2 immediate implants reached a value of between 40– and 49; 8 implants, 5 immediate and 3 delayed, reached a value of 50–59; 21 impacts, 11 immediate and 10 delayed, reached a value of 60–69; 6 implants, 1 immediate and 5 delayed, reached values of 70–79; and 3 implants, 1 immediate and 2 delayed, reaches values of 80–89.

4.7. Immediate Non-Functional Loading

The immediate load is the loading of the implant in the first week after its placement, although there are authors who speak of a shorter time interval, which is reduced to 48 h [37]. It is important to differentiate between immediate functional loads and immediate or aesthetic non-functional loads. The first refers to the prosthesis subjected to occlusal forces that are transmitted directly to the implant, and the second to the restoration outside occlusal contacts that prevent forces from being transferred to the dental implant. The implants of the immediate group of these three studies [21,28,30] that were immediately loaded without occlusion were in the aesthetic sector.

4.8. Observation Times

In general, observation times vary from study to study, with the lowest being 4 months and the highest being 60 months (5 years) [19]. Between these two chronological points, it can be confirmed that, within the existing variety, most studies have an observation time of 6 [24,25,27] to 12 months [22,26,28,29]. One study [23] conducted observations for 36 months, and 1 study made observations between 18 and 36 months [21].

Regarding marginal bone loss, measured by five studies, the authors shared the moment in which they obtained the changes in marginal bone for three studies [26,28,29] to be 12 months. Slagter et al. [19] evaluated this variable at two different times: the first was at 12 months of loading, like the studies mentioned above, and the second was at 5 years (60 months) after implant loading. The remaining study by Kamel et al. [25] was the earliest, 6 months after implant loading.

Considering the six studies that reported failures in the groups of immediate implants and/or delayed implants, the implantological failures occurred at different times depending on the study in question: Ribeiro et al. [21] reported three failures in the immediate implant group, which differed in terms of time at one month, 5.2 months, and 12 months; Tonetti et al. [23] obtained one failure with immediate implantation be-

fore the osseointegration of the piece although they did not specify the exact moment; Ebenezer et al. [24] extracted five failures, one immediate implant and four delayed implants, which occurred at 3 and 6 months, though the failures of two and three pieces went unspecified; Felice et al. [28] identified two failures in immediate implants at 2 and 7 months after implant loading; Checchi et al. [29] identified five failures in immediate implants at 3 months after placement, at the time of abutment connection, and at 9 months after loading and two failures in delayed implants at the time of abutment connection; and finally, Felice et al. [30] reported two failures in immediate implants that occurred at one month and the fourth month after placement.

4.9. Summary of the Evidence

Table 7 evaluates the quality of the evidence and the degree of recommendation of the studies that compare, on the one hand, the dichotomous variable, the number of implant failures, and, on the other, the continuous variable, marginal bone loss. There are 11 studies compared for implant failures and 4 for marginal bone loss. The level of certainty is considered high, so it can be concluded that it would be recommended to carry out conventional or delayed implantation in unit rehabilitations.

Table 7. Assessment of the quality of evidence from studies included in the meta-analysis.

№ of Studies	Study Design	Certainty Assessment					№ of Patients		Effect		Certainty	Importance
		Risk of Bias	Inconsistency	Indirectness	Imprecision	Other Considerations	Immediate Implants	Delayed Implants	Relative (95% CI)	Absolute (95% CI)		
IMPLANTOLOGY FAILURE (follow-up: range 4 months to 60 months)												
11	randomized trials	not serious	not serious	not serious	not serious	strong association	333 / 661 (50.4%)	328 / 661 (49.6%)	OR 3.47 (1.17 to 10.28)	277 more per 1000 (from 39 more to 414 more)	⊕⊕⊕⊕ High	
MARGINAL BONE LOSS AT THE END OF OBSERVATION TIME (follow-up: range 12 months to 60 months; Scale from: 0.13 to 1.06)												
4	randomized trials	not serious	not serious	not serious	not serious	none	115	115	-	MD 0.11 SD higher (0.1 lower to 0.33 higher)	⊕⊕⊕⊕ High	

CI: confidence interval; MD: mean difference; and OR: odds ratio.

4.10. Limitations

The limitations of this study are multifaceted and stem primarily from the constrained scope of the randomized clinical trials that were analyzed. These trials were selected based on stringent inclusion criteria to ensure comparability. However, this rigorous selection process resulted in a relatively small sample size, which may limit the generalizability of the findings.

One significant limitation is that most of the included studies did not offer a direct comparison between the different implantation protocols, namely immediate versus delayed or conventional. This lack of comparative data restricts our ability to draw definitive conclusions about the relative efficacy of these approaches.

Furthermore, this study is hindered by a high degree of heterogeneity regarding the observation periods for the implants. This variability in follow-up durations makes it challenging to synthesize the data and could potentially mask long-term trends or outcomes associated with the implants.

Another critical limitation is the absence of a systematic evaluation of marginal bone loss across the studies. Marginal bone loss is a pivotal indicator of implant success and longevity, yet the data on this parameter were scarce and inconsistent. This gap in the data severely hampers our capacity to assess the long-term viability of the implants.

Additionally, there was a notable deficiency in information regarding the primary stability of the implants. Primary stability is a key predictor of osseointegration success, and a lack of robust data on this front is a significant shortcoming of the current body of research.

Most pointedly, the study could not conduct a large-scale comparison of marginal bone loss results due to the limited number of clinical trials that reported this outcome. Of the

11 clinical trials examined, only 4 provided data that could be included in the meta-analysis. This small dataset undermines the strength of any conclusions that can be drawn about marginal bone loss associated with the different implantation protocols.

Considering these limitations, it would be highly beneficial for future research to include a more comprehensive measurement of marginal bone loss, ideally with a larger sample of studies that uniformly report this outcome. Such data can greatly enhance our understanding of the comparative effectiveness of immediate and delayed implant protocols and contribute to the optimization of dental implant strategies.

4.11. Clinical Recommendations

Based on the results of this study, dental professionals should prioritize delayed implant placement protocols after a period of bone healing to enhance implant survival and minimize marginal bone loss. Immediate implants may be considered for their aesthetic benefits and shorter treatment duration, which are factors that contribute to patient satisfaction. However, the decision between immediate and delayed implants must be tailored to each patient's specific clinical situation, with careful consideration of their anatomical conditions and personal treatment preferences. Ongoing research and clinical judgment are essential in determining the most appropriate treatment protocol.

5. Conclusions

Regarding the main objective, it can be surmised that there are significant differences in terms of survival and marginal bone loss between the experimental group, immediate implants, and the control group for delayed implants as follows:

1. The meta-analysis of implant failures clearly indicates that implants placed following a conventional protocol after bone healing fail less frequently than those placed immediately.
2. Considering the small number of clinical trials included in the meta-analysis with respect to marginal bone loss, it can be concluded that there is a tendency to favor implants placed using a delayed protocol in terms of less marginal hard tissue loss, although more studies are needed to corroborate these results.

The secondary objectives are provided as follows:

1. The aesthetic results obtained after the placement of an immediate implant are similar to those achieved with a conventional or delayed implant. It should be noted that the placement of an immediate post-extraction implant allows for the positioning of the prosthetic crown with or without occlusion immediately until definitive prosthetic rehabilitation, which considerably enhances aesthetics from the first phase of treatment.
2. Overall patient satisfaction with dental implant treatments is high for both study groups: immediate and delayed implants. The immediate placement of the implants has the advantage of a shorter treatment time, which is highly valued by patients.
3. There is no consensus in the literature analyzed that explicitly defines the indications for opting for immediate or conventional/deferred treatment, but there are determining factors to consider before choosing one modality over another.

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