*Review*

# Narrow Implants and Overdentures in the Total Rehabilitation of Atrophic Edentulous Jaws: Review of Clinical Aspects with Meta-Analysis

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**Abstract:** Background: The present study analyzes the clinical aspects of the use of small-diameter implants for the fixation of total overdenture-type prostheses on both totally edentulous dental arches. Materials and methods: This is a review of all randomized controlled trials of at least ten patients with a control group in which at least two narrow implants were placed, published between January 2010 and July 2023. Most databases were analyzed, and clinical studies involving the insertion of at least two narrow implants (<3.5 mm in diameter) were analyzed. Results: Studies showed that the survival rate of narrow implants varied from 78% to 100%. Conclusions: The results indicated that narrow-type implants have satisfactory and predictable clinical performance for the long-term stability of overdenture-type prostheses.

**Keywords:** narrow implants; jaw; overdenture

## 1. Introduction

Today, it is common to clinically encounter cases of total jaw edentulism. The reasons may vary from economic to socio-cultural factors. Treatment with dental implants offers a predictable solution for most situations encountered in routine clinical practice. However, the availability of bone is often a limiting factor in treatment planning [1,2]. The psychophysical component also often influences the patient's drastic choice to remain in this situation [2]. What is observed is a rapid resorption of the post-extraction ridge, much more rapid in the mandible than in the upper maxilla, with values of 0.2 mm per year of loss [2]. Obviously, resorption is different for different types of bone according to Misch and Cawood and Howell and Atwood's classification [3]. Often in mandibular anterior areas, there is more resorption on the vestibulo-lingual side [4]. This represents precisely one of the cases in which the use of narrow-diameter implants can help; one needs only to think of the two valid supports to build a total overdenture. The I.T.I. consensus of 2013 [5] defined implants with a diameter ≤ 3.75 mm as "narrow". The practicality of these implants is equivalent to their prosthetic simplicity. Often, the most common way to restore them is to insert ball attachments or locators. In addition, ball, locator, and magnet attachments are available from most implant manufacturers and are very versatile because they can be used for immediate loading. The use of narrow implants would therefore avoid major surgery for both operator and patient, thus reducing operator experience and patient morbidity [4,6]. This causes limitations for implant placement. In these cases, surgical procedures may be necessary to increase insufficient bone volume. However, these procedures require surgical skills to prevent possible complications such as post-operative pain, infection, nerve damage, bone fractures, bleeding, wound dehiscence, and implant failure.

This increased morbidity, together with a high cost and a longer healing and surgery time, raises the need for other treatment options [6].

Similarly, it is believed that in medically impaired or elderly patients, regenerative procedures carry a high risk of complications. Therefore, alternative concepts such as small-diameter dental implants are seeing increased interest in clinical and scientific terms. Already in 2014, Schiegnitz [6] indicated that avoiding regenerative procedures or other invasive surgical treatments with the use of narrow implants could expand treatment options, avoid more invasive procedures, and reduce patient morbidity and treatment time. The definition of narrow implants is inconclusive in published studies, but in general a narrow-diameter implant is taken to have a diameter $\leq 3.5$ mm. This general classification does not consider the different clinical indications for narrow implants. Therefore, the classification by Klein [2] was implemented in this systematic review, as it incorporates these parameters.

In this classification, narrow implants are divided into the following three categories:
Category 1: <3.0 mm ("mini implants")
Category 2: 3.0–3.25 mm
Category 3: 3.30–3.50 mm

The objective of this literature review is to assess the predictability of narrow-diameter implants as an alternative to other technically more complex procedures, based on survival rates and peri-implant bone height changes and its complications. Recommendations and guidelines for the application of narrow implants are also provided.

## 2. Materials and Methods

This study followed the Preferred Reporting Items for Systematic Reviews (Figure 1) and Meta-Analyses (PRISMA) statement. This revision is correctly registered on the Prospero system with number 462595. Therefore, the aim of this systematic review was to answer the focused question: in patients with edentulous jaws, what is the performance of removable overdenture-type prostheses supported by narrow implants (<3.5 mm in diameter), and how does it impact marginal bone loss, implant failure rate, and prevalence of biological and prosthetic complications? The primary question for the research has been captured in the PICO format (population, intervention, comparison, outcomes): Does the insertion of narrow implants with a ball or locator to support the overdenture (I) report the same clinical results (O) in randomized controlled studies in total edentulous jaw in comparison (P) with regular implants (C)? The inclusion and exclusion criteria were defined by the authors before the start of the study. Inclusion criteria were all human-based randomized controlled trials (RCTs) which were published in English with at least 10 patients and one year of follow-up after prosthesis delivery. All studies were designed to evaluate the clinical effectiveness of narrow implants to rehabilitate significant jaw atrophy. All analyzed studies were published between 1 January 2010 and 28 July 2023. The exclusion criteria were as follows: studies reporting the same data as subsequent publications by the same authors, systematic reviews, comments and letters to the editor, case reports, in vitro studies, animal model studies, and case series. Relevant systematic review papers, as well as reference lists of all included articles, were manually searched to identify additional publications. Full-text screening, study selection, and data extraction were performed in duplicate, and disagreements were resolved by consensus.

### 2.1. Eligibility Criteria

Eligible studies must have the following characteristics: (I) randomized controlled trials; (II) prospective studies; (III) studies with at least ten edentulous patients who received removable overdenture-supported restorations with narrow implants in both jaws; (IV) comparisons between narrow and standard implants in the same study; and (V) published in English.
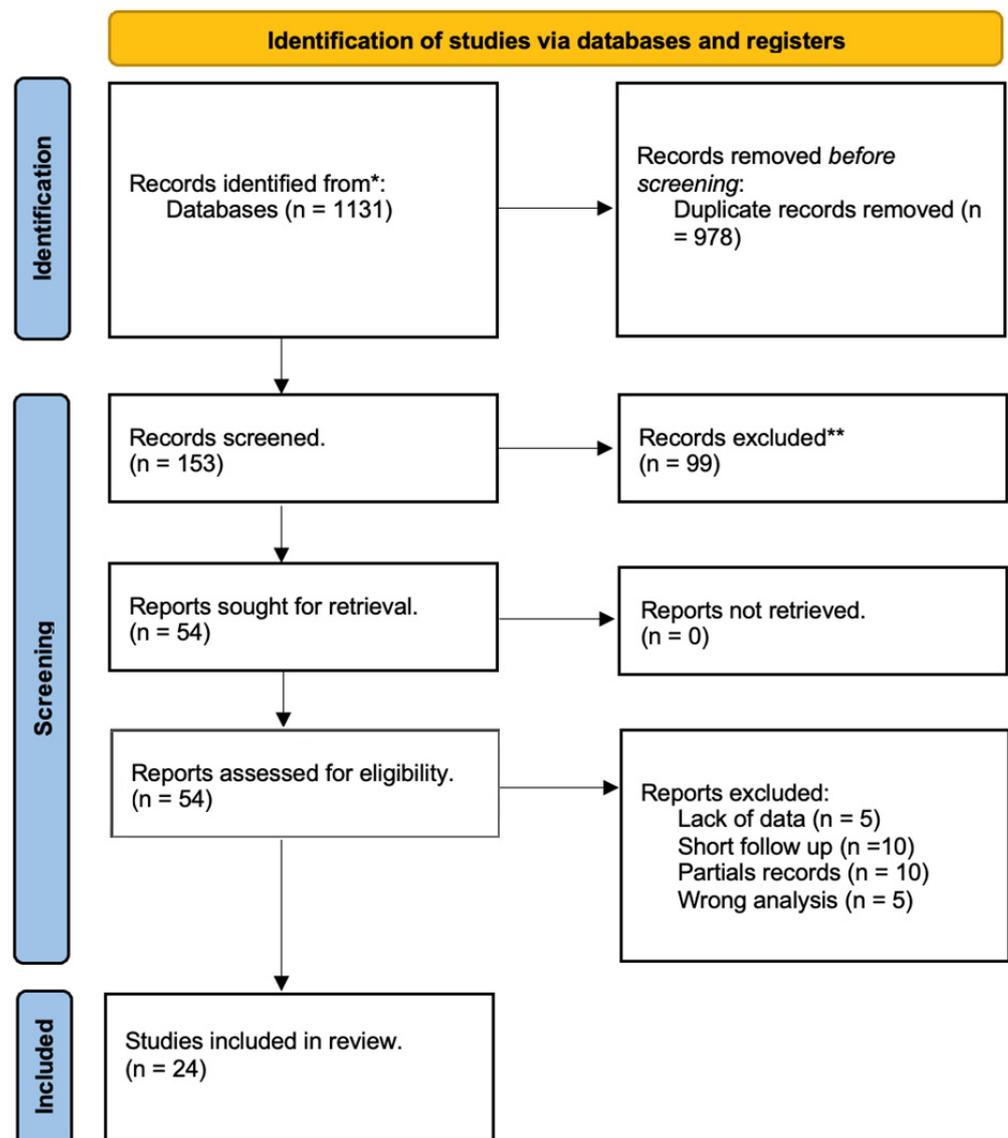
**Figure 1.** Search strategy flow chart: the search involved electronic databases * (MEDLINE, Embase, and Cochrane Library). ** Records were excluded for lack of relevance.

### 2.2. Exclusion Criteria and Outcome Measures

This review excluded (I) reviews, letters, case reports, conference abstracts; (II) retrospective studies; (III) in vitro studies; (IV) preclinical studies. The primary outcome examined by this systematic review was the survival rate of narrow dental implants supporting fully edentulous arches. The secondary outcomes were marginal bone levels, biological complications, and overdenture failure. All data collected and analyzed were measured before surgery and at each annual recall, for at least 3 months of follow-up. The results contained at least one of the following variables: implant success rate with subsequent survival; bleeding and probing depth with plaque index; marginal bone loss; masticatory function; and patient satisfaction.

*2.3. Search Strategy, Selection Criteria, and Data Extraction*

The search involved electronic databases (MEDLINE, Embase, and Cochrane Library). The following word combination was used: "narrow implants OR narrow implants AND edentulous AND overdenture". In addition, the review bibliography was analyzed and compared. Two independent reviewers (A.R. and M.M.) performed a three-stage screening procedure of all selected studies. First, the titles were analyzed to eliminate inappropriate studies. Then, all abstracts were examined, and only the selected studies were involved in the full-text reading.

## 3. Results

*3.1. Identified Articles*

The electronic database search identified 1131 references, and after removal of duplicates, 153 records remained. Subsequently, the Phase I screening yielded 54 full texts. Of these, 24 articles were selected for review. The following variables were extracted from these studies (Table 1): author/year, type of study, type of implant (test group/control group), type of attachment (ball/locator), follow-up, marginal bone loss.

**Table 1.** Main characteristics of included studies: TG (test group); CG (control group); Y (year); M (months); X (missing data).

| Study | Type of Studies | Implant Test Groups<br>1. TG at Baseline<br>2. TG at Last Follow-Up | Implant Control Groups<br>1. CG at Baseline<br>2. CG at Follow-Up | Type and Diameter of Implants<br>1. Narrow Implant<br>2. Regular Implant | Type of Attachments | Type of Prosthesis | MBL<br>1. Narrow<br>2. Regular | Follow-Up |
|---|---|---|---|---|---|---|---|---|
| Faot [7] | Comparative study | 1. 61<br>2. 61 | 1. 21<br>2. 21 | X | Locator | Overdenture | 0.2 + (−1.2) | 3 Y |
| Ahn [8] | Longitudinal prospective study | 1. 25<br>2. 23 | 1. 6<br>2. 6 | 1. 3.2 mm IMTEC Sendax MDI System<br>2. 4.5 mm IMTEC Sendax MDI System | Locator | Overdenture | 1. 0.3 + (−1.8)<br>2. 0.4 + (−1.4) | 36 m |
| Scarano [9] | Longitudinal prospective study | 1. 152<br>2. 123 | 1. 45<br>2. 35 | 1. 2.6 Anthogyr<br>2. 4.2 Anthogyr | Ball | Overdenture | X | 5 m |
| Giannakopoulos [10] | Randomized clinical trial | 1. 100<br>2. 93 | 1. 45<br>2. 42 | 1. 3.1 mm BEGO Implant<br>2. 4.1 BEGO Implant | Locator | Overdenture | 0.4 + (−1.3) | 1 Y |
| Reis [11] | Randomized clinical trial | 1. 24<br>2. 20 | 1. 8<br>2. 4 | 1. 2.9 mm Neodent<br>2. Not specified | Ball | Overdenture | 0.34 + (−1.3) | X |
| Payne [12] | Randomized clinical trial | 1. 80<br>2. 65 | 1. 25<br>2. 20 | X | Ball | Overdenture | 1. 0.44 + (−1.3)<br>2. 0.45 + (−0.87) | 1 Y |
| Tymstra [13] | Comparative study | 1. 60<br>2. 30 | 1. 23<br>2. 19 | X | Ball | Overdenture | X | 5 m |
| Schuster [14] | Cohort study | 1. 52<br>2. 50 | 1. 18<br>2. 15 | 1. 2.9 mm Neodent<br>2. 4.1 mm Neodent | Locator | Overdenture | 0.23 + (−0.8) | 3 m |
| Park [15] | Randomized clinical trial | 1. 55<br>2. 54 | 1. 20<br>2. 18 | 1. 3.1 mm NRline<br>2. 5.1 mm NRline | Ball | Overdenture | 0.34 + (−0.88) | 1 Y |
| Ma [16] | Randomized clinical trial | 1. 117<br>2. 108 | 1. 40<br>2. 28 | X | Ball | Overdenture | X | 1 Y |
| Possebon [17] | Cohort study | 1. 30<br>2. 21 | 1. 15<br>2. 13 | X | Ball | Overdenture | 1. 0.01 + (−0.23)<br>2. 0.43 + (−0.89) | 1 Y |
| Marcello-Machado [18] | Longitudinal prospective study | 1. 60<br>2. 53 | 1. 24<br>2. 21 | 1. 2.9 mm Neodent<br>2. 4.1 mm Neodent | Locator | Overdenture | 0.6 + 1.2 | 1 Y |
| Bielemann [19] | Randomized clinical trial | 1. 102<br>2. 98 | 1. 44<br>2. 39 | X | Locator | Overdenture | 0.6–1.4 | 1 Y |
| Mundt [20] | Comparative study | 1. 402<br>2. 289 | 1. 280<br>2. 200 | 1. 2.3 mm 3M ESPE<br>2. 4.5 mm 3M ESPE | Ball | Overdenture | X | 2 Y |
| Catalan [21] | Randomized clinical trial | 1. 14<br>2. 13 | 1. 14<br>2. 14 | 1. 3 mm IMTEC Sendax<br>2. 4.5 mm IMTEC sendax | Ball | Overdenture | X | 1 Y |

**Table 1.** *Cont.*

| Study | Type of Studies | Implant Test Groups 1. TG at Baseline 2. TG at Last Follow-Up | Implant Control Groups 1. CG at Baseline 2. CG at Follow-Up | Type and Diameter of Implants 1. Narrow Implant 2. Regular Implant | Type of Attachments | Type of Prosthesis | MBL 1. Narrow 2. Regular | Follow-Up |
|---|---|---|---|---|---|---|---|---|
| Preoteasa [22] | Longitudinal prospective study | 1. 69 2. 34 | 1. 23 2. 20 | 1. 3 mm IMTEC Sendax 2. 4.5 mm IMTEC Sendax | Ball | Overdenture | 0.89 + (−1.96) | 3 Y |
| Jofre [23] | Randomized clinical trial | 1. 90 2. 78 | 1. 34 2. 24 | 1. 1.8 mm IMTEC Sendax 2. 4.5 mm IMTEC Sendax | Ball-bar | Overdenture | X | 36 m |
| Stanford [24] | Randomized clinical trial | 1. 96 2. 93 | 1. 45 2. 42 | 1. 2 mm Intralock 2. 3.8 mm Intralock | Ball | Overdenture | X | 24 m |
| Maryod [25] | Longitudinal prospective study | 1. 120 2. 115 | 1. 46 2. 46 | 1. 1.8 mm 3M ESPE 2. Not Specified | Ball | Overdenture | 1. 0.84 + (−0.86) 2. 0.23 + (−0.45) | 36 m |
| Mangano [26] | Longitudinal prospective study | 1. 231 2. 201 | 1. 34 2. 29 | 1. 2.7 mm Direct metal laser Ball sintering (DMLS) 2. Not specified | Ball | Overdenture | 0.8 + (−0.95) | 3 Y |
| De Souza [27] | Randomized clinical trial | 1. 236 2. 198 | 1. 126 2. 100 | 1. 2 mm Intralock 2. 3.8 mm Intralock | Ball | Overdenture | X | 12 m |
| Hasan [28] | Longitudinal prospective study | 1. 70 2. 65 | 1. 19 2. 19 | 1. 1.8 mm 3M ESPE 2. Not specified | Ball | Overdenture | 1. 0.8 + (−0.9) 2. 0.03 + (−0.23) | 1 Y |
| Temizel [29] | Longitudinal prospective study | 1. 99 2. 97 | 1. 35 2. 33 | 1. 1.8 mm 3M ESPE 2. Not specified | Ball | Overdenture | X | 2 Y |
| Jawad [30] | Randomized clinical trial | 1. 44 2. 43 | 1. 22 2. 21 | 1. 2.1 mm Astratech 2. 3.8 mm Astratech | Ball | Overdenture | X | 6 m |

### 3.2. Included Studies and Outcomes

The 24 studies that met the inclusion criteria are listed in Table 1. All selected studies were RCTs, longitudinal studies, or cohort studies, published between 2010 and 2023, and conducted in university settings. All included a single treatment option for each patient in each of the 3325 implants, of which there were 2390 narrow (<3.5 mm) and 935 regular with diameter > 3.5 mm. In all studies, implants were placed in the edentulous jaw or edentulous jaw. Follow-up ranged from 3 months to 3 years. The diameter of the dental implants included implants with a diameter of <3.5 mm and implants with a larger diameter of between 3.5 and 5 mm.

### 3.3. Biological Complications

The prevalence of biological complications for removable overdentures were 0% and 11.1%, respectively. The reported biological complications were bleeding, pain and edema, and an increased plaque accumulation with an increase (>4 mm) of pocket probing depth [31].

### 3.4. Meta-Analysis

The meta-analysis was conducted using the random model effect because of the high heterogeneity ($I^2 = 80\%$) among the five included studies that compared the MBL of narrow and regular implants. All signs and symptoms of TMD were considered for the statistics. The overall effect, reported in the forest plot (Figure 2), revealed that there was no difference in MBL between the two groups (mean difference 0.20; CI:95%, −0.25, 0.66; Z:0.88, P:0.38). This statistical analysis found that there was no difference in MBL between the two groups of implants used for overdenture.
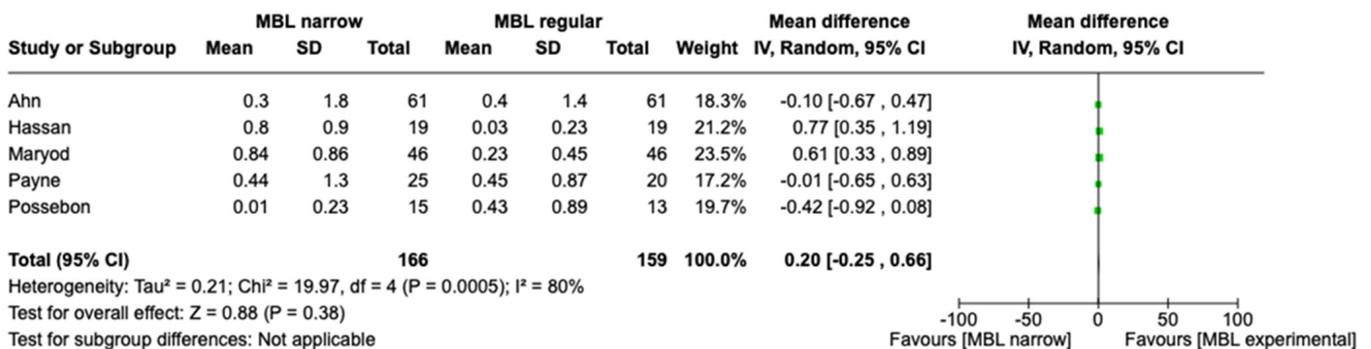
| Study or Subgroup | MBL narrow | | | MBL regular | | | Weight | Mean difference IV, Random, 95% CI | Mean difference IV, Random, 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Total | Mean | SD | Total | | | |
| Ahn | 0.3 | 1.8 | 61 | 0.4 | 1.4 | 61 | 18.3% | −0.10 [−0.67 , 0.47] | |
| Hassan | 0.8 | 0.9 | 19 | 0.03 | 0.23 | 19 | 21.2% | 0.77 [0.35 , 1.19] | |
| Maryod | 0.84 | 0.86 | 46 | 0.23 | 0.45 | 46 | 23.5% | 0.61 [0.33 , 0.89] | |
| Payne | 0.44 | 1.3 | 25 | 0.45 | 0.87 | 20 | 17.2% | −0.01 [−0.65 , 0.63] | |
| Possebon | 0.01 | 0.23 | 15 | 0.43 | 0.89 | 13 | 19.7% | −0.42 [−0.92 , 0.08] | |
| **Total (95% CI)** | | | **166** | | | **159** | **100.0%** | **0.20 [−0.25 , 0.66]** | |

Heterogeneity: Tau² = 0.21; Chi² = 19.97, df = 4 (P = 0.0005); I² = 80%
Test for overall effect: Z = 0.88 (P = 0.38)
Test for subgroup differences: Not applicable

Favours [MBL narrow]    Favours [MBL experimental]

**Figure 2.** Forest plot of included studies shows a CI of 95% [8,12,17,25,28].

### 3.5. Quality Assessment and Risk of Bias

Using RoB 2, the risk of bias among the studies analyzed was estimated and reported in Figure 3. Regarding the randomization process, 70% of studies ensured a high risk of bias. The 25% allocation concealment provides an increased risk of bias. Only 75% of studies excluded a performance bias, and 100% reported all outcome data; however, all the included studies presented a reporting bias. Only two out of three studies showed a low risk of incurring bias (Figure 3).
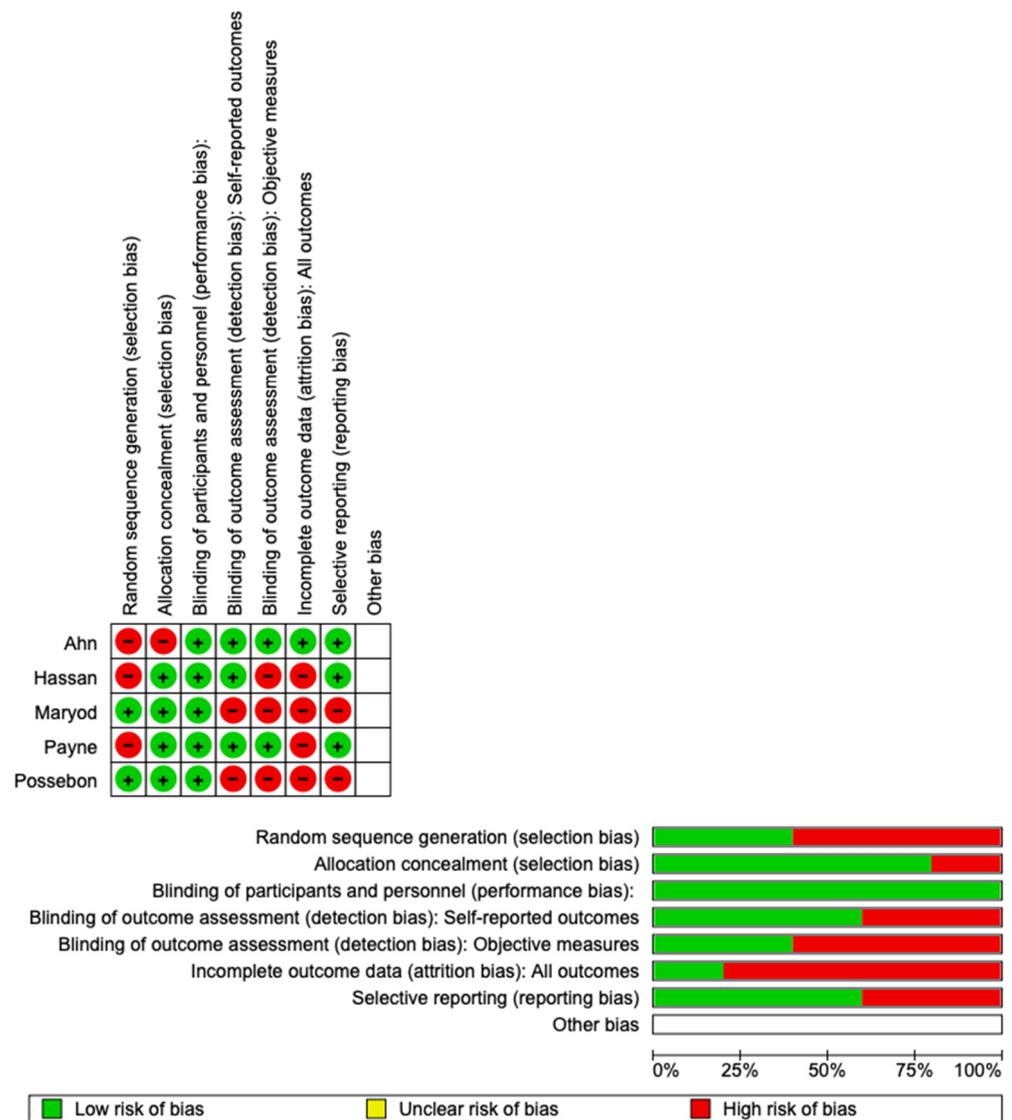
**Figure 3.** Risk of bias of included studies: green represents a low risk of bias; red represents a high risk of bias [8,12,17,25,28].

## 4. Discussion

The present review provided the opportunity to analyze the clinical data offered by the literature on cases of total rehabilitation with overdentures for edentulous jaws [32,33]. The same review, enriched with a meta-analysis of the data, produced an implant success rate of 89% (0.07–0.17 mm) for the use of narrow implants compared with regular ones to support prostheses. It was found that the success rate was higher in studies with longer follow-up times. Obviously, the predictability of narrow implants was tested, and a higher survival rate was demonstrated for studies that used locator attachments [34]. The use of narrow implants to support overdentures showed a lower average MBL rate than control groups with standard implants for all follow-up times. Some studies that opted for the immediate loading technique revealed an increase in MBL compared to loading at 3 months [30,35–37]. An important study conducted by de Souza [27] states that the narrow implant can have a very similar success rate to the regular implants as long as the biomechanical rules are respected in dental zone positions 3.2/3.3 and 4.2/4.3. Another interesting study by Machado [38] showed that increasing the number of implants does not lead to greater success, but rather increases patient morbidity during the convalescence period. Maryod [25] focused on the type of loading, preferring conventional 3-month

loading to immediate loading, as very often the materials used in relining for the delivery of the restoration generate peri-implant inflammatory responses, altering the initial healing. The meta-analysis revealed that, depending on the loading performed, the articles in which immediate loading was the option, the bone loss was greater. The risk of fracture was also assessed in this review, and it was observed that narrow implants are sometimes prone to fracture due to mechanical stresses between prosthetic components, the implant platform, and the surrounding bone surface [7–9,39]. In fact, important research has shown that they are only used in cases where the thin ridge is significantly resorbed. The meta-analysis carried out showed aggregate implant survival values of 96%, which do not deviate from the values cited in the scientific literature [40]. Follow-up is also important, because in this review, higher success rates were observed for narrow implants with a follow-up of up to 5 years. A study by Rosa [41] demonstrated that a mandibular overdenture supported by 2 narrow implants at 2 years of follow-up had a high success rate. Of extreme importance was evaluating the loss of marginal bone, and Bielemann [19] pointed out in a longitudinal study that the predictability of implants is directly proportional to marginal bone loss. The values established in the literature where bone loss is considered acceptable are less than 2 mm at a 1-year follow-up, with a maximum of 0.2 mm for each subsequent year [31,42,43]. The values produced by the meta-analysis revealed only one study in which a bone loss of approximately 1.03 mm for narrow implants was presented at a 3-year follow-up. The better the retention, the less reabsorption there will be [19]. In one study, Schuster suggested an immediate mandibular overdenture on 3 locators at a 3-year follow-up showed less bone loss than with standard implants. This study shows that locator attachments on narrow implants also provide stability to the prosthesis with low resorption intervals measured in the follow-up [14]. This review had the opportunity to compare spherical and locator attachments. Most of the articles cited involved the use of spheres, which in the meta-analysis showed slightly higher success rates than studies involving the use of locators, with values of 0.3 + −0.5 [15,44–46]. Immediate loading was shown to be more effective and predictable with the use of ball-and-socket attachments with a 2-year follow-up. Therefore, the meta-analysis revealed that bone resorption values did not differ significantly between the two groups [28]. However, no study has evaluated functional performance using objective parameters. Another parallel study reported that the number of failed narrow implants was significantly higher than standard implants, possibly because very narrow diameters between 1.8 and 2.1 mm were used [26,29,30]. Giannakopoulos demonstrated that narrow implants with a diameter of 3.0 mm showed higher success rates than regular implants in thin crests [10]. Machado, on the other hand, observed that shrinkage with a diameter of 3.0 to 3.5 mm has long-term predictability with different but not as variable success rates compared to regular shrinkage [18,47].

A study included [48] in this systematic review noted that bone loss around the attachment of the sphere is greater than the attack of the locator. The results obtained show that the bone loss around the locator connection is less than the sphere and locator. Also, Shady [49] confirmed this aspect in a study where clinical and radiographic parameters were compared between systems of attachment of the ball and localizer for single-implant mandibular overdenture. In another included study [50], the average marginal bone loss was less around the larger-than-standard implant, although it was not statistically significant. Based on the results of this systematic review, it can be stated that the locator experienced fewer complications than the ball attachment system, but it is not statistically significant to prefer it to the ball attachment. Furthermore, the locator can be used with a reduced interocclusal space and has a lower risk of fracture than the ball [49].

Lower minor soft tissue and periodontal complications and marginal bone loss were observed with the locator than the ball [51].

However, the outcome of this study should be carefully generalized; more low-risk randomized trials with good methodological quality are needed in the near future to strengthen the trials [52].

Furthermore, most of the included studies used two implants per patient in the regular groups, while the number of narrow implants varied from two to four [22,24,53]. This success may result from the larger number of implants per patient rather than the difference in implant diameter, while the placement of four implants instead of two for mandibular overdentures is clinically more predictable [2]. Of course, the most significant advantage is that narrow implants lend themselves to minimally invasive surgical protocols without the need for bone augmentation procedures in a limited alveolar bone volume [17,21,54]. Thus, the patient's morbidity and fear of surgery would be reduced [51]. All of the studies included in the review assessed residual, non-augmented ridges, so even in the assessment of postoperative pain and discomfort, the placement of four narrow implants caused a higher level of pain than the placement of two regular implants, as the surgical site and thus a longer postoperative period [12–14,16]

The result that emerges from this review is certainly the great advantage of the narrow implant diameter, which can be placed in very limited bone contexts without invasive GBR surgery. However, the limit of this review is that the treatment outcomes of NDIs should be compared with those of RDIs with augmentation procedures to reflect the actual clinical situation.

## 5. Conclusions

The results obtained indicate that it is possible to achieve long-term clinical performance with narrow implants as an overdenture support in edentulous jaws if the biological criteria are met. Therefore, it is proposed as a satisfactory treatment option for all those with low initial bone thickness. The results indicated that both implants have satisfactory clinical performance. Narrow-diameter implants have positive therapeutic results compared to standard implants in terms of implant survival rate and marginal bone loss. Therefore, narrow-diameter implants could be an alternative treatment option in situations of limited alveolar bone volume. More randomized trials are needed to confirm this hypothesis of using conventional narrow-diameter implants as overdenture retainers.

**Author Contributions:** Conceptualization, A.R. and A.M.P.; methodology A.M.P.; software, R.D.A.; validation, A.R. and C.A.; formal analysis, R.D.A.; investigation, R.D.A.; resources, A.R.; data curation, R.D.A.; writing—original draft preparation, A.R.; writing—review and editing, A.R.; visualization, C.A.; supervision, C.A.; project administration, C.A.; All authors have read and agreed to the published version of the manuscript.

**Data Availability Statement:** Data are contained within this article.

**Conflicts of Interest:** The authors declare no conflicts of interest.

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