

Review

# Complete Full Arch Supported by Short Implant (<8 mm) in Edentulous Jaw: A Systematic Review

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**Abstract:** Background: This study aimed to evaluate survival rate, marginal bone levels, and full arch prosthetic success on short implants when placed in areas of severely resorbed and edentulous mandibles. Methods: This is a systematic review of all randomized controlled trials of at least 10 patients with a control group in which bone augmentations were performed that were published between January 2010 and February 2023. Only three relevant studies met the inclusion criteria. Results: This review showed that short-term dental implant survival rates ranged from 94.2% to 97.4% with a five-year follow-up, and prosthetic success rates ranged around 62% during the same follow-up. The mean marginal bone level values of the affected short implants ranged from 0.2 mm to 0.6 mm. Conclusions: The data obtained demonstrated that short dental implants positioned with criterion and precision as a full-arch fixed support are a valid therapeutic choice for the medium–long-term rehabilitation of severe edentulous mandibular atrophy.

**Keywords:** full arch; mandibular atrophy; short dental implants; short implants; prosthetic



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## 1. Introduction

Nowadays, the use of a conventional full arch for the treatment of edentulous patients is a common treatment approach [1]. Often due to severe vertical and horizontal resorption of the alveolar ridge, complications such as lack of stability and reduced masticatory function are often associated with lower full dentures. To improve mechanical and esthetic function, the use of mandibular full-arch restorations (fixed or removable) supported by conventional implants in the interforaminal region has advanced, which have achieved a predictable mode with high success rates (87% to 100%) [1,2]. However, maxillary resorption due to periodontal disease and vertical and horizontal bone loss can reach a severity that prevents or even limits conventional implant rehabilitation treatments. In addition, sovereign anatomical structures such as the inferior alveolar nerve can be irreparably damaged when using conventional length implants [3]. To overcome these situations, the literature often proposes more invasive techniques for the clinician to refer to, such as vertical bone augmentation [4], osteogenic distraction [4], and lateralization of the inferior alveolar nerve [4]. However, limiting elements such as dental phobia, morbidity in the postoperative period, economic costs, and treatment difficulty may negatively influence the patient in wanting and being able to accept implant therapy [5]. Recently, some systematic scientific reviews and clinical studies have shown that the use of short implants results in low failure and complication rates and, most importantly, have found minimal marginal bone loss for single and partial restorations supported by short implants placed in the mandible. Recent studies have shown that the use of tissue-level implants in patients with severe bone atrophy appears to be a viable option when applied in the rehabilitation of the entire immediate loading interval [6]. However, we still lack sufficient evidence on the durability of full-arch prosthetic restorations supported by short implants (<8 mm) in

completely edentulous and severely resorbed mandibles [7,8]. On the other hand, Group 1 of the Sixth ITI Consensus Conference, analyzing the definition of “short,” determined that “short dental implants” are all dental implants  $\leq 6$  mm in size [9]. Today, scientific evidence from several clinical studies in the literature found no statistically significant differences in implant survival rates or observed no changes in marginal bone loss (MBL) of short dental implants compared to standard-length dental implants. Often, the combined use of short implants and bone regeneration techniques may result in less surgical complexity [9]. Other studies have shown that when more discrepancy in crown-to-implant ratio is present, the more this increases the risk of mechanical problems, but the risk of peri-implant marginal bone loss does not increase. Another important aspect to evaluate and consider is the area of implant installation, because the likelihood of failure increases when implants are installed in low-density bone, such as in the maxilla in the posterior region [8–13]. However, there is no consensus on the short-term survival rate of implants in the posterior maxilla and mandible [10]. Some authors have advanced limited success rates, while others have found high success rates for short implants placed in the maxillae [10–12].

The purpose of this study was to systematically review the literature regarding implant survival rates, marginal bone levels, and the prosthetic success of full-arch short dental implants used for the rehabilitation of severe mandibular atrophy.

## 2. Materials and Methods

This study followed the Preferred Reporting Items for Systematic Review (Figure 1) and Meta-Analyses (PRISMA) statement. Therefore, the aim of this systematic review was to answer the focused question: in patients with edentulous jaws, what is the performance of fixed and removable full-arch restorations supported by short ( $\leq 6$  mm) implants with regard to marginal bone loss, the implant failure rate, and the prevalence of biological and prosthetic complications? The primary research question was captured in the PICO (population, intervention, comparison, outcomes) format: do short implant as full-arch support (I) report the same clinical results (O) in randomized controlled trials in total edentulism of the mandible (P) as a substitute for long 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) with at least 10 patients and a 1 year of follow-up after prosthesis delivery and which were published in English. All studies were designed to evaluate the clinical efficacy of short implants to rehabilitate severe posterior mandibular atrophy. All the studies analyzed were published between 1 January 2010 and 28 February 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 searched by hand to identify additional publications. Full-text screening, study selection, and data extraction were performed in duplicate, and disagreements were resolved by consensus.

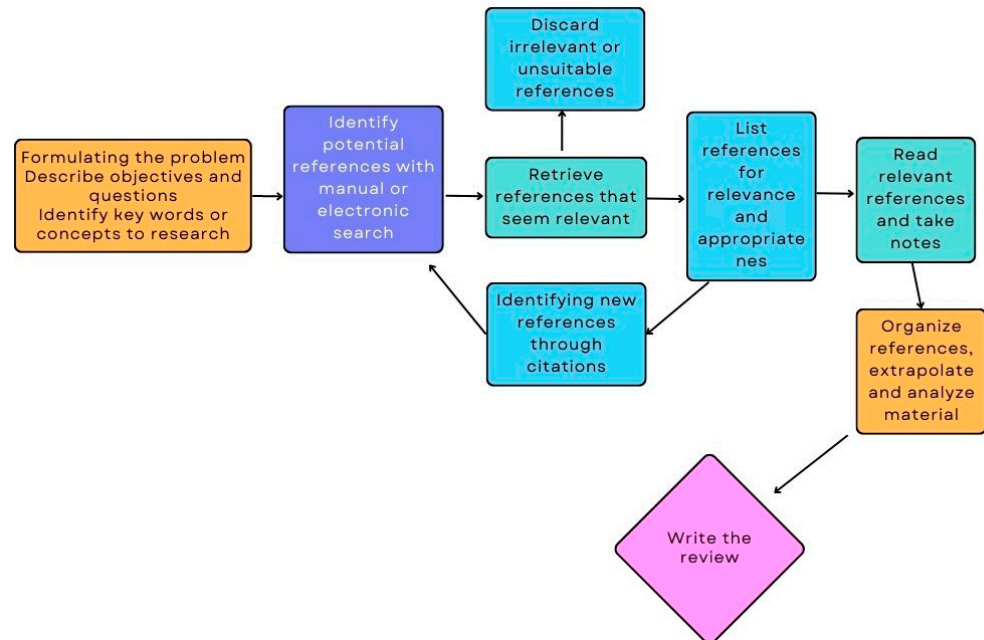
### 2.1. Eligibility Criteria

Eligible studies must have the following characteristics: (I) randomized controlled trials, (II) prospective studies, (III) studies with at least ten edentulous patients receiving fixed or removable full-arch restorations supported by short implants in the mandible, (IV) comparisons between short and standard implants works in the same study, and (V) published in English. In this study, the threshold to consider an implant short was a length of  $\leq 8$  mm.

### 2.2. Exclusion Criteria

In this review, the following were excluded: (I) reviews, letters, case reports, conference abstracts; (II) retrospective studies; (III) in vitro studies; (IV) preclinical studies; (V) studies with fewer than 4 short implants; (VI) studies with a follow-up of less than 1 year after

loading; (VII) studies describing short implants with a length greater than 8 mm; (VIII) other types of restorations (single crowns, fixed partial dentures); (IX)—short implants placed in the grafted areas; (X) absence of data on implant length; and (XI) failure to attempt to contact the author for eligibility purposes.



**Figure 1.** Flowchart guidance for authors in writing a systematic review.

### 2.3. Outcome Measures

The primary outcome examined by this systematic review was the survival rate of short dental implants supporting full arches. Secondary outcomes were marginal bone levels, biological complications, and prosthesis failure. All data collected and analyzed were measured preoperatively and at each annual recall, for at least 1 year of follow-up.

### 2.4. Search Strategy

The search involved electronic databases (MEDLINE, Embase, and Cochrane Library). The following combination of words was used: “short implant OR short implants OR extra short implant OR extra shorts implants AND mandible AND full arch”. In addition, review bibliographies were analyzed and compared.

### 2.5. Selection Criteria and Data Extraction

Two independent reviewers (A.R. and A.P.) performed a three-step screening procedure of all selected studies. First, the titles were analyzed to eliminate studies that were inappropriate. Then, all abstracts were reviewed and only selected studies were involved in reading the full text.

### 2.6. Risk of Bias

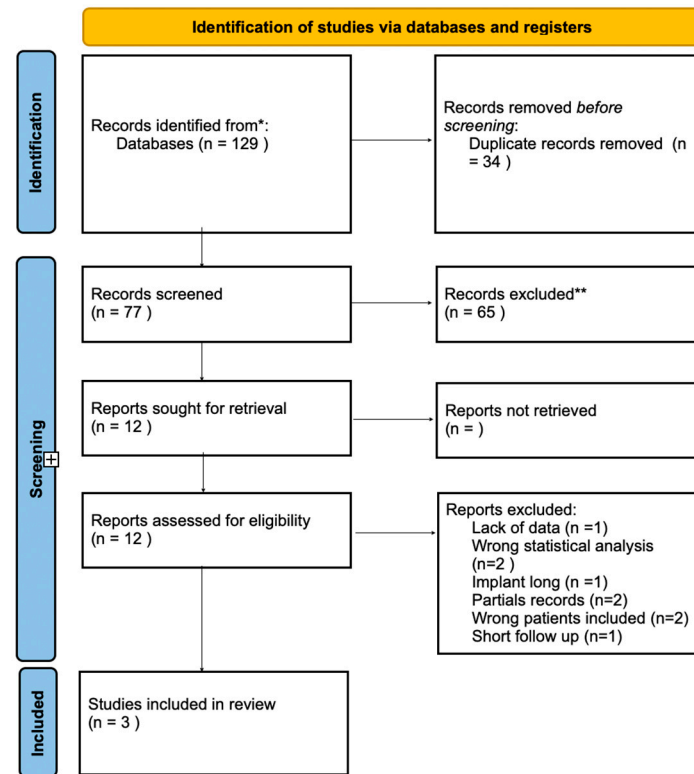
The quality of the studies included in the review was assessed by the reviewers (A.R. and A.P.) using the Cochrane Collaboration tool for assessing the risk of bias for randomized trials. The potential risk of bias was classified as low, high, or unclear. Any disagreements were discussed until resolved by consensus.

## 3. Results

### 3.1. Identified Articles

The electronic database search identified 129 references, and after removal of duplicates, 34 records remained. Subsequently, phase I screening yielded twelve full-text

articles; after phase II, nine were excluded (Table 1), while the remaining three articles were included as randomized controlled trials (Figure 2).



**Figure 2.** Search strategy flowchart: \* The search involved electronic databases (MEDLINE, Embase, and Cochrane Library). \*\* Records were excluded for lack of relevance.

**Table 1.** Excluded studies with reasons.

| Authors                   | Title   | Years | Reasons for Exclusion   |
|---------------------------|---|-------|---|
| Alsabeeha et al. [14]     | Mandibular single-implant overdentures: preliminary results of a randomised control   | 2011  | Implant short length > 8 mm   |
| Calvo-Guirado et al. [15] | Evaluation of extrashort 4-mm implants in mandibular edentulous patients with reduced bone height in comparison with standard implants: a 12 month results              | 2015  | Lack of data  |
| Shaarawy et al. [16]      | The Effect of Varying Implant Position in Immediately Loaded Implant-Supported Mandibular Overdentures  | 2013  | Patients or data reported in other included studies with longer follow-up.        |
| Tymstra et al. [17]       | Maxillary anterior and mandibular posterior residual ridge resorption in patients wearing a mandibular implant-retained overdenture                                     | 2011  | Statistical analysis is comprehensive and not divided by short and long implants. |
| Slotte C. et al. [18]     | Four-millimeter implants supporting fixed partial dental prostheses in the severely resorbed posterior mandible: Two-year results.                                      | 2012  | Records only for partial dental prostheses  |
| Zadeh HH. et al. [19]     | Marginal bone level and survival of short and standard-length implants after 3 years: An open multi-center randomized controlled clinical trial                         | 2018  | Statistical analysis is comprehensive and is only for long implants.              |
| Felice P. et al. [20]     | Posterior jaws rehabilitated with partial prostheses supported by 4.0 × 4.0 mm or by longer implants: One-year post-loading results from a randomised controlled trial. | 2016  | Records only for posterior jaws   |

**Table 1.** *Cont.*

| Authors                  | Title  | Years | Reasons for Exclusion  |
|--------------------------|--|-------|--|
| Aiuto R. et al. [21]     | Rehabilitation of Edentulous Jaws with Full-Arch Fixed Implant-Supported Prosthesis: An Approach with Short and Ultrashort Implants and Metal-Free Materials | 2020  | Follow up < 1 years  |
| Tsigarida A. et al. [22] | Peri-Implant Diseases and Biologic Complications at Implant-Supported Fixed Dental Prosthesis in Partially Edentulous Patients                               | 2020  | Patients or data reported in other included studies with longer follow-up. |

3.2. *Included Studies*

The three studies that met the inclusion criteria are shown in Table 2. All of the selected studies are RCTs published between 2010 and 2022 and conducted in a university setting. All included a single treatment option for each patient. A total of 178 implants, including 90 short ( $\leq 6$  mm) and 88 standard implants with lengths  $>6$  mm, were placed in 30 patients. In all studies, the implants were placed in the edentulous mandible. Only the results of mandibular implants were considered. Two studies had a follow-up of 5 years, while one had only a follow-up of 3 years. Regarding the length of dental implants, the short implant group included implants of 5/6 mm in length. The control groups had a variety of implant lengths ranging from 11 to 11.5 mm. Two studies presented cases of immediate loading.

3.3. *Characteristics of the Study’s Population*

Sample size ranged from 7 to 30 patients. All totally edentulous with an average age of 62.7 years, were treated with short implants in the mandible. The study demonstrated no significant effect of age on any outcome (marginal bone loss and proportion of implant failure).

3.3.1. *Implant Characteristics*

The length distribution of the implants was:  $15 \times 5$  mm,  $75 \times 6$  mm,  $13 \times 11.5$  mm, and  $75 \times 11.5$  mm. For statistical purposes, the implant lengths were divided into groups 1 and 2 (length  $\leq 6$  mm and length  $\leq 11.5$  mm), representing 90 short (50.56%) and 88 long (49.43 mm) implants, respectively. Similarly, the implants were divided into two groups: normal diameter  $\alpha$  ( $\varnothing 4.0$ – $\varnothing 4.1$  mm;  $n = 120$ ; 67.41%) and large diameter  $\beta$  ( $\varnothing 5.0$ – $\varnothing 6.0$  mm;  $n = 68$ ; 32.59%) implants. Statistical analysis found no statistically significant differences between the groups on the results evaluated [23,24].

**Table 2.** Main characteristics of studies.

| Study                  | Test Groups:<br>1. Tg at Baseline (M-F)<br>2. Age (Mean, Y)<br>3. Tg at Last Follow Up | Control Groups:<br>1. Cg at Baseline (M-F)<br>2. Age (Mean, Y)<br>3. Cg at Follow Up | Short Implants<br>1. N Short Implants at Baseline<br>2. N Short Implants at Follow Up | Regular Implants<br>1. N Regular Implants at Baseline<br>2. N Regular Implants at Follow Up | Type of Implant:<br>1. Manufacturer<br>2. Length of Short Implants<br>3. Length of Long Implants | Type of Prosthesis  | Follow Up |
|------------------------|--|--|---|---|--|---|-----------|
| Cannizzaro (2014) [23] | 1. 7 (0:7)<br>2. 62 +- 9.4<br>3. 7   | 1. 8 (0:8)<br>2. 58 +- 9.8<br>3. 8   | 1. 15<br>2. 14  | 1. 15<br>2. 13  | 1. Supershort NanoTite (Biomet 3i)<br>2. 5 mm<br>3. 11.5 mm                                      | 1. Fixed screw-retained full arch with distal cantilevels | 60 months |

Table 2. Cont.

| Study             | Test Groups:<br>1. Tg at Baseline (M-F)<br>2. Age (Mean, Y)<br>3. Tg at Last Follow Up | Control Groups:<br>1. Cg at Baseline (M-F)<br>2. Age (Mean, Y)<br>3. Cg at Follow Up | Short Implants<br>1. N Short Implants at Baseline<br>2. N Short Implants at Follow Up | Regular Implants<br>1. N Regular Implants at Baseline<br>2. N Regular Implants at Follow Up | Type of Implant:<br>1. Manufacturer<br>2. Length of Short Implants<br>3. Length of Long Implants | Type of Prosthesis  | Follow Up |
|-------------------|--|--|---|---|--|---|-----------|
| Guida (2020) [24] | 1. 15 (5:10)<br>2. 63 +- 6.3<br>3. 13  | 1. 15 (12:3)<br>2. 61 +- 8.6<br>3. 14  | 1. 75<br>2. 75  | 1. 75<br>2. 75  | 1. Osseospeed Tx, AstraTech, Dentsply Sirona, Molndal<br>2. 6 mm<br>3. 11 mm                     | 1. Fixed screw-retained full arch with distal cantilevels | 36 months |
| Guida (2022) [25] | 1. 15 (5:10)<br>2. 63 +- 6.3<br>3. 13  | 1. 15 (12:3)<br>2. 61 +- 8.6<br>3. 14  | 1. 75<br>2. 75  | 1. 75<br>2. 75  | 1. Osseospeed Tx, AstraTech, Dentsply Sirona, Molndal<br>2. 6 mm<br>3. 11 mm                     | 1. Fixed screw-retained full arch with distal cantilevels | 60 months |

### 3.3.2. Surgical Parameters

This study uses a quantitative analysis of the surgical approach (one time or two time). Only one study among those elected followed the one-stage surgical protocol, placing 56 implants differently from all other elected studies that followed a two-stage surgical approach. Most of the implants, about a number of 150, were placed by elevating a mucoperiosteal flap and then suturing it. Only the remaining 38 were placed with the flapless technique [23]. The reporting of postoperative surgical complications was rare, 13 patients reported postoperative bleeding and belonged to the mucoperiosteal flap elevation group; however, it regressed within 24 h. Therefore, evidence regarding this variable is still lacking. Menini et al. [26] demonstrated regarding the surgical approach that the one-stage implant insertion surgery can be successfully applied when using two extra-short splinted implants, with no significant differences in clinical outcomes compared with the two-stage approach.

### 3.3.3. Types of Prosthetics and Prosthetics Parameters

In this review, two types of prosthetic restorations were analyzed: fixed and removable. Evidently, these two types of restorations have differences in the type of material, biomechanics and distribution of masticatory forces, and patient/worker compliance to perform proper oral hygiene [23,24].

Most of the implants in the following study underwent a conventional final loading protocol (90 days after implant placement) (n = 140). Only two studies used immediate loading protocols 24/48 h. The results were divided into two groups: immediate/early loading (Group 1) vs. conventional loading (Group 2). Subgroup analysis revealed that the implant failure rates for Groups 1 and 2 were 0.6% and 2.3%, respectively.



Prosthetically, 23 fixed restorations were divided into 15 screw-retained and 8 cemented. The overall prevalence of prosthetic complications was 31.5%, and the average marginal bone loss was 0.9 mm. A limitation was found in the presence of distal cantilevers; in one study, a distal cantilever fracture was reported in an 11.5 mm long implant-supported restoration after 2 months of loading. In this case, the reported solution was an additional implant installation on each side and a new restoration with shorter cantilevers. Therefore, to date, it is not possible to determine which prosthesis is more suitable from the obtained analyses. Certainly, fixed prosthesis has more limitations if all prosthetic biomechanics criteria are not met, but more tests are needed to establish this link.

#### 3.4. Marginal Bone Loss

The MBL values reported in this review have been broken down by implant groups. Pooled overall marginal bone loss was 0.12 mm (0.07–0.17 mm). For fixed full-arch restorations, the average was 0.11 mm. For the removable full-arch restoration, the marginal bone loss was 0.14 mm [23,24].

#### 3.5. Biological Complications

The prevalence of biological complications for fixed and removable reconstructions 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 [23,24].

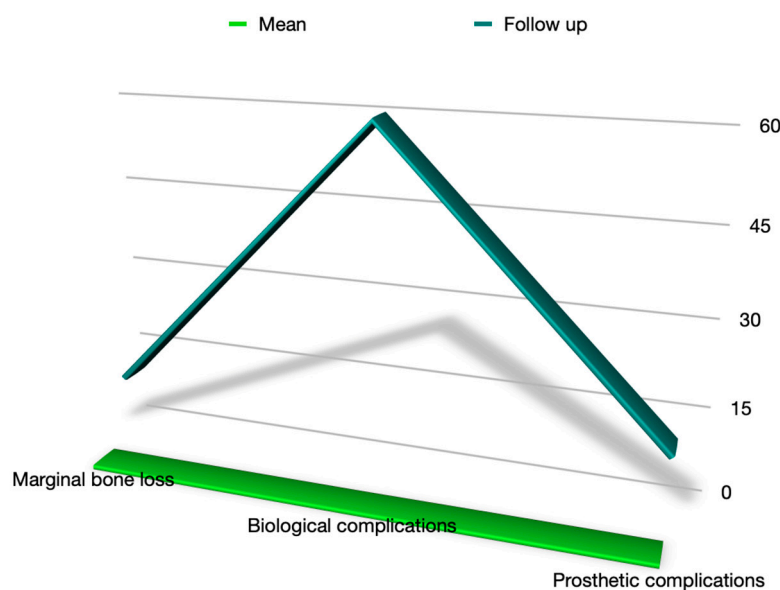
#### 3.6. Prosthetic Complications

The prosthetic complications encountered are low. We found studies reporting a loosening of a prosthesis screw after 2 months and four debondings out of five restorations. Therefore, on the basis of these data, fixed restorations show an exceptionally higher prosthetic complication, approximately 31.8%, while for full-arch removable restorations, the difference was 2.6%. Prosthetic complications of removable restorations included bar repair, sleeve wear, and denture relining [23,24].

#### 3.7. Follow Up

The follow-up period ranged from 12 to 60 months; however, one study reported results from a 120 month follow-up, where only the first 12 months were considered for comparison purposes [23,24].

An explanatory diagram of the mean outcome in the three selected articles is shown in Figure 3: the x-axis of the panel expresses the follow-up periods in months (60), the y-axis expresses the outcome of this review. No major statistical differences were found, only prosthetic complications on full arch with distal cantilevers demonstrated a difference in the mean at the 60 month follow-up (Figure 3).



**Figure 3.** Explanatory diagram of the mean of outcomes in the three selected articles.

#### 4. Discussion

This review considered whether full prosthetic arches supported by short ( $\leq 8$  mm) implants confer success in the aesthetic/functional restoration of completely edentulous mandibles. The concept of short implants has been described and evaluated in recent years, but it has not yet been adequately defined with regard to the length and diameter that are sufficient to have surgical and prosthetic predictability. In this review, implants with an “osseointegrable surface length” of less than or equal to 8 mm were chosen to guide the search for articles in the literature [27]. An average marginal bone loss of about 0.13 mm was found to correlate with a randomized trial that studied 75 short implants and reported average values between 0 and 2 mm for the same follow-up period of 3–5 years, as described by Cannizzaro et al. [23]. In contrast, a systematic review by Seeman and Bruggenkate et al. [7–13,27–29] found a significant effect of an increased diameter on the marginal bone loss of short implants supporting single crowns. The bone loss of short implants in the first year is significantly better than that of long implants. It can be argued that the type of prosthetic rehabilitation provided on a short implant plays a critical role on the outcome of bone loss. Blanes Rj et al. [30] in a review showed that the disadvantageous ratio of implant length to superstructure height does not result in bone loss for both short and long implants. Of interest is the study by Tsigarida et al. [31], who, in a review, reported high survival rates for implants supporting fixed full-arch restorations in the mandible. Immediate loading procedures have high survival rates for both fixed and removable restorations. However, there are differences in the number of implants, implant characteristics, complications, and costs between these two types of prostheses. Rameh et al. [32] in a review showed that survival rates of short implants until full-arch support are high regardless of the length or position of the inserted implant. More biological complications were found in standard implants, especially for splinted prostheses, which were associated with fewer technical complications. The results of this review demonstrated that, when used correctly, short implants achieve predictable long-term results, provided that they are placed following a comprehensive surgical and prosthetic protocol based on the various biomechanics parameters essential for optimizing long-term prognosis. The survival rate of the implants placed in this study (97.7%) parallels the systematic review performed by Srinivasan et al. [33], who observed high survival rates (98.6%) for short implants with a rough surface (6 mm) placed in the mandible under various prosthetic restorations. Carosi et al. [8] in a study showed that out of 14 patients with a complete mandibular arch, only five implants failed, with an overall implant survival rate of 96.9%. No definitive prostheses failed, with a prosthetic success rate of 100%. The failed implants



were successfully replaced without definitive problems before the final prostheses were made, with an overall treatment success rate of 100%.

In addition, it was observed that about 75% of failures of short implants were early failures. The survival rate of short implants in this study is comparable to the survival rate (96%) of longer implants placed in heterologous bone by various surgical techniques. Another important study by Slotte et al. [34] showed that the 12 month survival rate of 100 short implants (4 mm) was 95.7 percent, and 92.3 percent at 24 months, which is slightly lower than another study by Renouard et al. [28], who reported a survival rate of short implants placed in the mandible and loading of 94.6 percent at two years. As mentioned earlier, the reasons for the good results with short implants may be related to a high initial primary stability and the effective use of residual bone volume with high primary bone-to-implant contact in dense bone structures. Renouard et al. [28] also showed in a recent review how the failure rate with short implants is related to surgical operator learning curves, osteotomy preparation (regardless of bone density), the use of surface-machined implants, and placement in sites with low bone density [35].

The prevalence of biological complications was not relevant to the type of prosthetic restoration. The most common biological event observed was residual plaque accumulation and increased (>4 mm) pocket probing depth at various follow-ups. The relationship between plaque accumulation and gingivitis or periodontitis is well documented in the literature as an important late risk factor for implant failure. Linde et al. [27] had already shown that plaque accumulations around implants induce local inflammation and progressive marginal bone loss over years. In the studies considered for this review, none of them evaluated and found risk factors that could lead to peri-implant pathology or signs of peri-implantitis [17,36]. Carosi et al. [2] in another study showed that a total of 160 implants were placed in thirty-seven patients, while in three patients, both arches were rehabilitated. Forty full arch rehabilitations were performed, of which only fourteen were in the mandible, and only five implants failed with an overall implant survival rate of 96.9%. BoP was detected in about six implants (3.7%) and sixteen implants had a superficial amount of plaque, with a plaque score of 10%. Lian et al. [37], in a review, showed that for fully edentulous mandibles, short implants are a reliable therapeutic alternative, as survival and MBL were not different from those of inserted long implants.

In contrast, it was shown in this study that the prevalence of prosthetic complications was very different for both types of prostheses loaded on short implants (fixed or removable). In a review, Guida et al. [17,24,25,30,33,36,38] showed that failures with fixed full-arch restorations were more frequent and common and reported that the prosthetic failure rate reached 62.5 percent, considering that seven prostheses were installed and three debondings of five restorations and three fractures of the prosthetic structure occurred. This could be due to the presence of the distal cantilevers. Very interesting is the review by Morris et al. [39], who, in a study, demonstrated that when 13 arches were treated with about 64 short implants with minimum insertion torque value of 20 Nc, the implant and prosthetic survival rates were 100%. Eight patients were restored with permanent hybrid fixed zirconia or acrylic resin prostheses. Two patients were restored with titanium bar frameworks and removable overdentures. No prosthetic complications were reported for the definitive prostheses. However, these results should be interpreted with caution. In contrast, Cannizzaro et al. [23] used full-arch screw-retained fixed restorations and found only screw loosening during the 1 year follow-up. The restorative failures most reported by the author were loosening, loss of retention, rod adjustment, rod tension, cantilevers, and relining. In an interesting systematic review conducted by Al Tarawneh et al. [40], satisfactory clinical and aesthetic results were found for full-arch implant restoration using monolithic zirconia, thus increasing short-term success. To date, the rate of technical complications associated with this type of restoration is still minimal, and survival rates are very high. As the concept of short implants remains an evolving abstraction (less than or equal to 8 mm), two different calculations were performed in this review—(1)  $\leq 9$  mm and (2)  $\leq 5$  mm—as a threshold for short length implants. Indeed, it was observed that

the greater the length of the implants used, the lower the failure rate of these implants. Telleman et al. [38] in his review, however, did not find this increase in survival rate using long implants alone. The question of a probable compensation of the reduction in implant length with an increase in the diameter of the implant remains controversial at present. In this review, no significant difference was found between implant diameter and outcomes of marginal bone loss and implant failure rate once the majority of implants used were of regular diameter. Conversely, the least favorable results were found to be related to implants of larger diameter rather than regular for all lengths. The results suggest that short implants need not have a large diameter to resist masticatory forces if the prosthetic axes are respected. Due to the thickness and blood supply (cortical bone) characteristics of the buccal and lingual bone walls, short and regular-diameter implants help to better dissipate masticatory forces over the crestal bone, reducing marginal bone loss. A study on finite element analysis by Himmlova et al. [41] and Anitua et al. [42] demonstrated that implant length plays a minor role in force distribution. From this *in vitro* study, in order to reduce the loss of marginal bone, it was recommended to modify the design of the implant, favoring rough surfaces and increasing the thread to favor and improve osseointegration. de Oliveira Melo et al. [43] noted in a finite element study that it is suggested that all short (4 mm) implants studied are apparently viable alternatives for the rehabilitation of atrophic mandibles. However, the 6 and 8 mm implants showed more favorable mechanical behavior than the 4 mm implants.

The clinical recommendations obtained from this review with the associated limitations dictated by the sparse literature were as follows:

- ◆ Short implants demonstrated the same survival rate as long implants;
- ◆ There are slight variations in marginal bone loss between short and long implants;
- ◆ Standard implants are associated with more biological complications when associated with GBR;
- ◆ Fixed prostheses with cantilevers are more prone to prosthetic complications.

Limitations of this review include the limited number of articles found in the literature and are selected and included with small sample sizes. The following limitations may be mainly due to the recent nature of the topic that the aforementioned review aims to address, as well as to the eligibility criteria applied during the study selection phase. Another limitation is that the studies included evaluated full-arch fixed restorations and no removable-type restorations. It is well documented that the two types of restorations exhibit different biomechanics behaviors and, therefore, a direct comparison should be made in detail [44].

## 5. Conclusions

Implant therapy has evolved significantly over the years due to growing experience, technical development, and procedures that enable treatment. This means that implant therapy has become available even for patients with little bone support. A 4 mm implant can be used in special clinical situations, as demonstrated in this study, and also in combination with longer implants. Designing a short implant for available preexisting bone seems to be a good alternative to time-consuming, often painful and expensive additional methods. From a specialist point of view, there are still indications where a short implant meets a required need very well. However, before long-term studies are available, this implant should be suitable primarily for well-experienced clinicians/specialists so as not to compromise the treatment outcome in difficult cases. Despite the limitations, the present systematic review concluded that fixed full-arch restorations supported by short implants are a viable option for the treatment of mandibular atrophy.

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

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