



Major clinical findings of short implants and virtual surgery: a systematic review

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Abstract

Introduction: After the confirmation and publication of the phenomenon known as osseointegration by Brånemark, dental implants have been used to repair total and partial edentulous jaws. However, the implants were long and had to be longer than 11 mm to be considered functional. Short implants compared to long ones require less remaining bone, reducing the patient's exposure to surgeries for bone grafting, the elevation of the maxillary sinus mucosa, and repositioning of the inferior alveolar nerve. Added to this, several dental treatments have benefited from this digital advance.

Objective: To review the literature on short implants installed in both dental arches, evaluating their advantages, disadvantages, indications, and contraindications in the context of virtual surgery.

Methods: The present study followed a systematic review model (PRISMA). The search strategy was performed in the PubMed, Scielo, Cochrane Library, Web of Science and Scopus, and Google Scholar databases.

Results: A total of 110 articles were found, 64 articles were evaluated and 35 were rejected for not meeting the GRADE classification, and only 29 articles were used in this study to compose the textual part. Based on these findings, it was found that in remote years, authors reported that regions with reduced bone height are favored with the use of short implants not only because of their dimensions but also because of their surface treatment, which suggests that it is an important factor for achieving 100% success rates. The advantages of short implants are related to the simplicity of the technique, installation of implants in remaining bone, avoidance of bone grafts that present questionable results in the increases in height of the posterior alveolar ridge of the mandible, reduction of treatment time, and

reduction of costs for the patient. A systematic review and meta-analysis studies analyzed the accuracy of implant placement using computer-guided surgery. A randomized study compared the precision of guided planning of new computer-assisted implant placement techniques, based on models that use CAD/CAM.

Conclusion: It was concluded that short implants are a reliable, safe, and practical alternative to be used in any necessary location or situation. They do not show bone loss or resorption over the years, nor are they at risk of fracture or any damage to patients. They are safe to use, as long as they have an adequate design, therefore, fundamental tools in the dental clinic.

Keywords: Implantology. Short implants. Success Score. Virtual surgery.

Introduction

After the confirmation and publication of the phenomenon known as osseointegration by Brånemark, dental implants have been used to repair total and partial edentulous jaws [1,2]. Reliably in most cases, implants promote a better, more comfortable, and healthy life for thousands of individuals around the world [3].

Dental implants have become a treatment of choice for many patients and professionals who wish to provide a better option to traditional removable or fixed prostheses [2,3]. At the beginning of the use of osseointegrated implants, the design of all the marks was more or less similar, with external hexagons and later with internal hexagons. But one factor was paramount and common to all: the implants were long, on average they should have lengths above 11 mm to be considered functional [4].

Thus, later on, with the evolution of engineering and more research, shorter implants arrived at that could meet the needs of these patients left out of the then treatments with conventional implants [4]. These implants are defined as fixations whose length is less than 10mm [5] and were developed given the need to serve an increasing number of patients with atrophic mandibles [1]. Short implants compared to long ones require less remaining bone, reducing the patient's exposure to bone grafting surgeries, the elevation of the maxillary sinus mucosa, and repositioning of the inferior alveolar nerve, constituting a great advantage [2,3].

Added to this, in the scenario of new digital technologies, several dental treatments have benefited from this digital advance. The development of dental computed tomography (CT) scanners has enabled powerful imaging capabilities and software applications, implementing guided dentistry [6]. In this sense, authors and other researchers have developed computational planning methods to relate CT data to the prosthetic plane and implanted drill guides with the placement of trajectories based on a drill according to the position of markers in the 3-D space of the CT [7,8].

In this context, the software developed by Columbia Scientific known as SimPlant made it possible to plan these cases. After the acquisition of Columbia Scientific by Materialize (Leuven, Belgium), they had a process to use fast-output fabrication of software-planned dental implant trajectories in bone and later in surgical drill guide teeth [9]. In this context, the optimization of faster and more accurate techniques by dental and postoperative surgeons with better results and quality of life has stimulated the development of numerous software and hardware for performing computer-guided surgeries (GC) [9,10].

In this aspect, the software allows the placement of implants, as well as the creation of a high-precision surgical guide for placing implants and prostheses in immediate loading in patients [10]. In addition, GC is indicated in cases where CT is recommended as a diagnostic tool, when accurate implant placement is imperative, and when longer implant lengths are desired for optimal use of available bone [11].

Therefore, the present study aimed to review the literature on short implants installed in both dental arches, evaluating their advantages, disadvantages, indications, and contraindications in the context of virtual surgery.

Methods

Study Design

The present study followed a systematic review model, following the rules of systematic review -

PRISMA (Transparent reporting of systematic review and meta-analysis, access available in: <http://www.prisma-statement.org/>).

Data Sources

The search strategy was performed in the PubMed, Scielo, Cochrane Library, Web of Science and Scopus, and Google Scholar databases, using scientific articles from 1998 to 2021.

Descriptors (MeSH Terms)

The main MeSH Terms used were "*Implantology. Short implants. Success Score. Virtual surgery*". For greater specification, the description "*Short implants and Success Score*" for refinement was added during the searches, following the rules of the word PICOS (Patient; Intervention; Control; Outcomes; Study Design).

Selection Of Studies And Risk Of Bias In Each Study

The Cochrane Instrument was used to assess the risk of bias of the included studies, and GRADE was used to classify the quality of articles to the type of study and scientific evidence.

Results

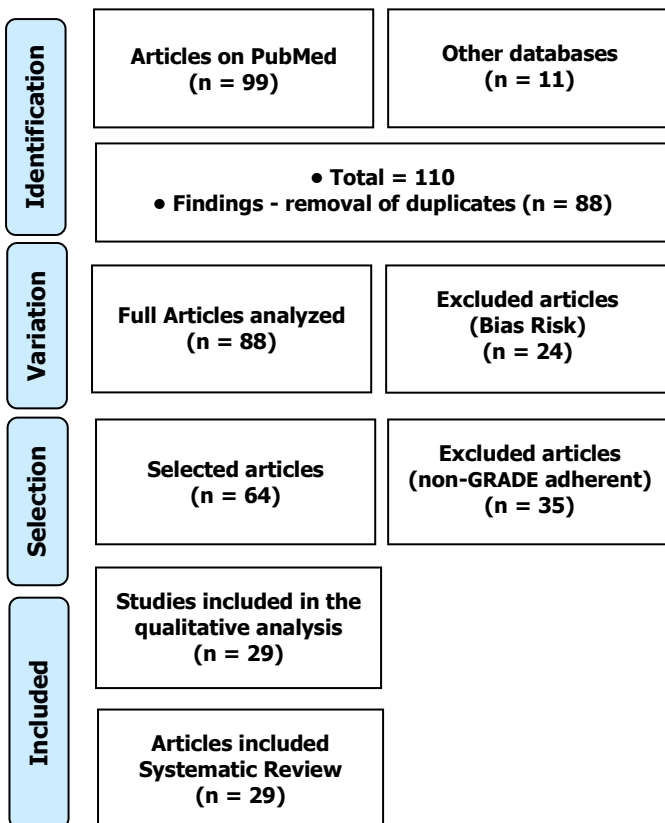
Summary Of Findings

Figure 1 shows that out of a total of 110 articles found, 64 articles were evaluated and 35 were rejected for not meeting the GRADE classification, and only 29 articles were used in this study to compose the textual part. Based on these findings, it was found that in remote years, authors [12] reported that regions with reduced bone height are favored with the use of short implants not only because of their dimensions but also because of their surface treatment, which suggests that it is an important factor in achieving 100% success rates. However, when short surface-enriched plasma implants were evaluated, it was observed that such implants can be used promisingly in patients with minimal bone height, being preferable, however, in combination with other longer implants.

Short implants are a viable option mainly for multiple implants in patients with posterior mandibles classified by Misch (2000) [13] as Classes I, II, or III – Division C, which is defined by not having an ideal bone height between the alveolar crest. and the mandibular canal. In this aspect, short implants are a surgical option for the rehabilitation treatment of atrophic posterior mandibles, but their indication depends on the patient's assessment, age, physical constitution, installation of

multiple implants, and bone quality. The advantages of short implants are related to the simplicity of the technique, installation of implants in remaining bone, avoidance of bone grafts that present questionable results in the increases in height of the posterior alveolar ridge of the mandible, reduction of treatment time, and cost reduction for the patient [14].

Figure 1. Flowchart - Article Selection Process.



Major Clinical Findings – Short Implants

Authors evaluated 55 short implants from 5 to 7 mm of the brand Endopore®, of the "Press Fit" type, with a porous surface in the rehabilitation of atrophic mandibles in the posterior region, in 40 patients, over 5 years. The implants were installed in the premolars and molars region and a total mucoperiosteal flap, piezo surgery or conventional flap was used depending on the bone type found. Healing was expected for 4 months. Then proceeded to the 2nd surgical stage. Prosthetic primary stability – 25 Ncm reverse torque. Prosthetic installation with occlusal load, using acrylic resin single crowns (cemented or screw-retained), crowns with several splint elements and overdentures. Six months after the initial load, the definitive prostheses were installed, with a torque (rotation) of 30 Ncm. A radiographic follow-up was performed for 1, 6 and 12 months after prosthetic installation and then annually. Failures in the prosthesis, implant and complications were observed. The initial period of loss of a 4.1 x 7mm

implant in the 2nd premolar. 8 implants were lost after loading (4 implants – single crowns; 3 implants – splinted prosthesis on another implant; 1 implant – overdenture – loss of 1 implant without loss of overdenture). Bone loss of 1mm was observed for the 5mm implant and bone loss of 2mm for the 7mm implant [15].

Still, other authors evaluated clinical studies on implants <10mm in length to determine their success in implant-supported prostheses in atrophic mandible, considering that short implants are useful in constructive procedures in clinical situations with limited vertical bone height. According to the authors, implant placement in the posterior region may be limited due to physical conditions, for example, limited vertical bone height, due to maxillary sinus expansion or proximity to the inferior alveolar nerve. In total, 6193 short implants were investigated from 3848 participants. The observation period was 3.2 ± 1.7 years (mean \pm SD). The cumulative survival rate (RSE) was 99.1% (95% CI: 98.8-99.4). The biological success rate was 98.8% (95% CI: 97.8-99.8), and the biomechanical success rate was 99.9% (95% CI: 99.4-100.0). Observing greater success in implants with a rough surface. The authors concluded that short implants are successful treatment options for patients with atrophic alveolar ridge [16].

In this context, the placement of short dental implants has been proposed as an alternative to reduce the surgical risks related to advanced grafting procedures. This study aimed to simulate the biomechanical behaviors and influences of short implant diameters under various bone quality conditions using a validated finite element (FE) simulation model. The CT imaging and CAD system were combined to build the FE models with IDE from 6mm in length to 6, 7 and 8mm in diameter under three types of bone qualities, from normal to osteoporosis. The simulated results showed that implant diameter did not influence bone von Mises strains under vertical load. Bone strains increased by about 58.58% in lower density bone under lateral loading. The implants were subjected to high tension by lateral and vertical loads and stress. It was observed that the bone strains of short 7 mm and 8 mm diameter implants were not different, and both were about 52% and 66% compared to the short 6 mm wide implants under lateral loads. The von Mises stresses of the SDIs and compartments were all less than the yield strength of the material under vertical and lateral loads. SDIs with a diameter of 7 mm or greater may have better mechanical transmission, at the same length in a viable state [17].

Other authors have evaluated the effect of implant length on marginal bone loss (MBL) and how it interferes with peri-implant health and how short implants

(<10mm) support fixed prostheses. However, they concluded that implant length did not affect peri-implant marginal bone loss. Short implants must be meticulously maintained to minimize marginal bone loss and increase the long-term survival rate. Due to the shorter length, having adequate bone around these implants is crucial for long-term success. Thus, the authors suggest using an internal abutment-implant connection, which can minimize marginal bone loss, thus increasing the implant survival rate [18].

Added to this, Srinivasan et al. (2014) [19] tested the hypothesis that short, rough-surfaced 6mm implants provide predictable survival rates. A total of 690 short 6 mm implants were evaluated and it was observed that 266 implants installed in the maxilla failed, and 364 installed in the mandibular also failed, in a follow-up period of 1-8 years. Thus, the overall survival rate in the maxilla and mandible was considered to be 94.7% to 98.6%, respectively. Failures that occurred prematurely were around 76%. These results allowed the authors to conclude that short implants (6 mm) are a predictable treatment option, providing favorable survival rates. Failures were predominantly early and survival in the mandible was slightly higher.

Virtual Implants – Major Aspects

A systematic review study analyzed the accuracy of implant placement using computer-guided surgery and compared the design and outcome of virtual treatment versus in vitro, clinical, or cadaver studies. Also, it compared the accuracy of half-guided implant surgery with that of fully guided implant surgery. A total of 186 articles were reviewed, and 34 met the inclusion criteria. Information on 3,033 implants was analyzed in 8 in vitro studies (543 implants), 4 cadaver studies (246 implants), and 22 clinical studies (2,244 implants). Significantly fewer horizontal apical deviations and angular deviations were observed in in vitro studies compared to clinical and cadaver studies, but there were no statistically significant differences in apical coronal deviation or vertical deviation between groups. Compared with semi-guided surgery, fully guided implant surgery showed significantly less horizontal coronal deviation for cadaver studies, significantly less horizontal apical deviation for clinical studies, and significantly less angular deviation for clinical and cadaver studies [20].

Also, a meta-analysis study analyzed the accuracy of dynamic computer-aided implant surgery (dCAIS) systems when used to place dental implants and compared their accuracy with static computer-aided implant surgery (sCAIS) and placement systems. freehand implants. Of 904 potential articles, the 24

selected evaluated 9 different dynamic navigation systems. The global mean and 3D angular deviations from entry for clinical studies were 3.68° and 1.03 mm, respectively. No significant differences were found between the different dCAIS systems. These systems were significantly more accurate than the sCAIS and freehand implant placement systems. As such, dCAIS systems allow the placement of high-precision implants with an average angle of less than 4° [21].

Besides, a randomized study compared the precision of guided planning of new computer-assisted implant placement techniques, based on models that use CAD/CAM stereolithographic surgical models with or without metallic sleeves. No implants failed and there were no complications. Forty-one implants were placed using surgical templates with metal sleeves, while 49 implants were placed using a surgical mold without metal sleeves. There was a statistically significant difference in the angle and the vertical plane, with lower values for implants placed with a surgical mold without metallic sleeves. In the test group, closed sleeves were more accurate compared to sleeves open in the angle and the horizontal plane [22].

Discussion

Several studies have shown that short implants can present success rates comparable to those of longer implants and that they can be a safe alternative if well indicated and executed, taking into account all the factors responsible for the increase in success rates [13,19, 23-25]. There is a consensus among the authors that one of the most important aspects that must be evaluated before the indication of a short implant is related to the interocclusal distance in areas of low bone height, since implants placed in these regions with reduced ridge height, without the bone graft procedure will result in longer prosthetic crowns [26,27], which may compromise aesthetics and create a vertical cantilever in which there is a reduced or even inverted crown/implant ratio, which may lead to bone loss by increasing the stress from occlusal forces [13,28,29].

The availability of bone height is often a determining factor in the length of implants. In situations of extremely reduced bone volume, the surgeon can perform bone grafting procedures, which result in higher cost, higher morbidity and longer treatment. Another possibility for these anatomical limitations is the use of short implants with which it is possible to achieve high success rates. This evidence is reported in studies that have revealed similar results for short and long implants [19,28,29].

Studies published in the literature with 6 mm, 7 mm, 8 mm, 8.5 mm and 9 mm implants stated that

these implants are comparable to long implants, making rehabilitation possible without the need for grafting, thus simplifying the surgical phase and making -the least costly [19,24,25]. Santiago Júnior et al., (2010) [26] reported that the length of the implant has no relevant effect on the distribution of tension, given that the highest concentration is present in the crest of the alveolar bone around the implant, which supports the use of shorter implants, as they offer specific advantages in certain clinical situations. In the study by Monje et al. (2013) [18] concluded that marginal bone loss around short implants is not influenced by implant length.

Other authors have also reported that short implants can still be installed in a single step with similar predictability to long implants [1-3]. However, Galvão et al. (2011) [5] concluded that the two-step surgical protocol is safer for the procedure with short implants. The high failure rates found for short implants were associated with the incidence of forces of great magnitude in the posterior region of the dental arches [13]. Santiago Júnior et al., (2010) [26] also highlighted that short implants have a disadvantage in terms of primary stability and force distribution, but their length can be compensated for by the incorporation of threads, which will lead to an increase substantial in the bone-implant contact area.

According to Rettore Júnior et al., (2009) [27], these can be related to the increase in the height of the prosthetic crown, inverting the crown/implant ratio; more intense occlusal forces in the posterior regions where the use of short implants is more frequent, due to the presence of the maxillary sinus and mandibular canal in the maxilla and mandible respectively; low bone density in these posterior regions.

Conclusion

Short implants are a reliable, safe, and practical alternative to be used in situations with reduced bone height, but good thickness in well-selected cases. They do not show bone loss or resorption over the years, nor are they at risk of fracture or any damage to patients. They are safe to use, as long as they have a proper design, correct technique, and careful planning. These are fundamental tools nowadays that can be a good solution for specialists who want to provide the best to their patients.

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Data sharing statement

No additional data are available.

Conflict of interest

The authors declare no conflict of interest.

Similarity check

It was applied by Ithenticate@.

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