

Biomechanical Evaluation of Short Implants for Prosthesis: Review Article

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ABSTRACT

Short implants are a successful alternative for patients who require adjunctive therapy, such as bone graft, before longer implants are placed. This also provides the advantages that the treatment is less invasive, more cost effective, and less tiring for the patient. Short implants can expand the limits of current implant treatments. This review aims to biomechanically prosthetically examine short implants.

KEYWORDS: Short implant; Biomechanical; Prosthesis

INTRODUCTION

The goal of advanced dentistry is restoring normal contour, function, comfort, aesthetics, speech and health of the patients. The dental implant is accepted as a promising method to replace a single tooth or multiple adjacent missing teeth, or to support a removable prosthesis for a completely edentulous patient [1]. Implant placement is important for the success of osseointegration and function. The height and width of the residual alveolus and surrounding anatomical structures can determine the proper position and path of insertion of dental implants [2]. Events leading to integration of an implant into bone, and hence determining the performance of the device, take place largely at the tissue implant interface. Development of this interface is complex and involves numerous factors. These include not only implant-related factors, such as material, shape, topography, and surface chemistry, but mechanical loading, surgical technique, and patient variables, such as bone quantity and quality, as well [3]. At the same time, factors belonging to the patient such as smoking, alcohol, drug use, resistance of the immune system, blood values, systemic diseases should be taken into consideration [4]. Therefore, patient related factors and the use of the appropriate implant affect the success rate [5]. In many studies, researchers [6,7] have tried to reduce

the stress on the cortical alveolar crest and minimize bone loss by increasing the contact area of the bone-implant interface. Therefore, they have focused on making changes in the diameter and / or length of the implant or changing the attachment design and shape [6-9].

While implants are classified according to the time of surgery, the material used, the time of placement and the prosthetic structure; The factors affecting biomechanics in terms of prosthesis should also be well known, and the right implant should be selected according to biomechanical rules. Biomechanics; external effects of applied forces, internal effects (stress analysis), mechanical properties, heat transfer and fluid mechanics. Moreover, other experimental studies showed that the mechanical strain is a key parameter for bone remodeling, in which the physiological strain values can lead to bone formation while extreme low or high strains can cause bone resorption [10]. Jain et al. [11] stated that the biomechanical factors required for the success of the implant depend on the diameter of the implant, the crown-implant ratio, the bone quality, the presence of cantilever, the number of implants, implant design, surgical methods, implant-abutment connection, occlusion and splint indication. Choosing the implant length

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depending on the current bone quality, quantity and bite force is an important factor in the success of the implants and the life of the prosthesis. Thomas Driskell invented the Bicon system of dental implants in 1968, with the introduction of the 8-mm implant. Branemark introduced the 7-mm implant. The literature can therefore be divided into implants that are termed conventional "short implants" ranging from 7mm to 10mm length and "ultrashort implants" of length <7mm. Many companies have implants as short as 5mm in their armamentarium [12]. As an alternative to complex surgeries (those performed to allow the placement of longer implants or for biomechanical reasons), the use of dental implants with reduced length should be considered. Along with their simplicity, short-length implants allow for less expensive and faster treatment with reduced morbidity [13]. The viability and high success rates seen with short implants (while in the natural dentition a similar 'crown-to-root' ratio would be predictive of failure) can be explained by osseointegration, the crown-implant ratio, the macro geometric design of the implant, as well as physics and the distribution of forces [14]. The biomechanical rationale for short implants is that the crest of the implant takes the most load, while little stress is transferred to the apical portion. This review aims to biomechanically prosthetically examine short implants.

FACTORS AFFECTING SUCCESS OF SHORT DENTAL IMPLANTS FOR PROSTHODONTIC TREATMENTS

Length/Diameter Relationship

The searcher found that diameter is more effective at dissipating stress than implant length; because it is the crest of the bone where the maximum load takes place and less stress is transferred to the apical part [11,15]. Increasing length only increases primary stability; however, the larger implant not only increases the primary stability but also increases the functional surface area in the cortical bone and provides better distribution of occlusal forces. Finite element analysis also supported this concept and showed that implant length would not be the main factor affecting the transfer of occlusal loads to the bone-implant interface [11]. Chou et al. [16] compared implants with large-diameter long implants and narrow-diameter short implants according to their resistance to occlusal loads, and large-diameter short implants were compared to narrow-diameter long implants. The searcher reported that it distributed loads more evenly compared to that [16].

Implant's Surface

Implant manufacturers had developed different screw designs, with various macroscopic topography and various implant surfaces in order to improve biomechanical properties such as primary and secondary stability and to limit the extent of peri-implant bone loss. Malo et al. [17] showed that short implants used in both jaws may be a viable concept with comparable survival rates to longer implants, especially when oxidized implant surfaces are used. On the other hand, surface treatment with etching was not found that increased the performance of short implants [18]. Under conditions of insufficient bone amount and anatomical limitations, short implants with rough surfaces show superior clinical performances compared to flat surfaces. Also, the researchers provided that micro-rough short dental implants are a predictable treatment option, providing favorable survival rate [19]. Moreover, short implants whose surface was coated by titanium anodizing, led to a higher failure rate than those treated by sandblasted/large-grit/acid-etching (SLA). SLA surface exhibit both macrostructures and micro irregularities, which would especially benefit primary

stability [20]. Potential disadvantages of roughening the implant surfaces includes problems related to peri-implantitis and ionic leakage. Because of that care should be given to the implant surface properties selection.

Cantilever

The use of pontic or cantilever can be an alternative for clinical situations where the use of an ideal number of implants is not allowed due to bone resorption that does not allow the placement of other implants or even because of the financial limitations [21]. But studies showed that treatment with short implants, in cases where is not possible one implant for each missing tooth, the use of cantilever (especially distal cantilever) should be avoided due to unfavorable biomechanical behavior, which could increase the chances of treatment failure [21,22]. Beside that since the impact of a cantilever is similar to a force being exerted by an class I lever biomechanical force in implant supported prosthesis, it might jeopardize the health of its peripheral supporting bone. Since there are evidence to indicate the use of the short implants in distal extension edentulous area have a success rate comparable to long implants, in order to prevent stress concentration in implant's surrounding bone, the use of short implants in distal extension can be suggested [23].

Splinting

Splinting implants increases the functional surface area of support and transmits less force to the prosthesis, the cement, abutment screws and the implant bone interface especially when placed in soft bone [11]. Also, splinting short implants in the posterior region mainly enhances their stability to eccentric forces [24]. Yang et al. [25], suggested that splinting of two short implants has the same biomechanical effectiveness as splinting with a single long implant. Therewithal, Hingsammer et al. [26] stated that splinting short implants provides biomechanical advantages. But they suggested that crown-to-implant ratios should not exceed 1.7 to avoid increased early marginal bone loss [26]. Furthermore, the biomechanical advantage of splinting may be minor when patients present healthy anterior guidance and controlled occlusal clearance [24].

Implant/Abutment Connection

Implant / abutment connection preferences are more effective than implant surfaces in the reshaping phase, which is the biological process that allows implants to adhere to soft tissue [27]. Short implants might be expected to develop a greater maximum compressive stress in their coronal region in comparison with longer implants, which could lead to bone microfracture and crestal bone resorption [18]. Studies showed that platform switching reduces the maximum principal stress of short and long implants. Therefore, since the bone around the implant will be protected in short implants with platform switching concept. It has been reported that more successful results can be obtained without further surgery in cases with low bone height [27,28].

The Importance of Bone Type

It has been found that short implants in the mandible give more successful results than the maxilla. This is thought to be due to lower density in the maxillary posterior bone and thus lower bone contact [29]. Although short implants are the first alternative that comes to mind in the presence of insufficient vertical bone, they can cause unsuccessful results. Most of the failures are caused by resorption

caused by high occlusal stresses in the crestal region, especially in the posterior regions where masticatory forces are increased. It is stated that the reason for the failure of short implants is that these types of implants are generally used in the posterior maxilla, where the bone volume and quality is the lowest [6,7,30]. It should not be forgotten that the development of relatively high strain in the alveolar ridge is inevitable, regardless of the implant dimensions. The quality of alveolar bone is critical to control the development of regions of overstrain [31].

Using Short Implant in Immediate Loading

In the early phase of healing, a small movement of 10 to 20 μ m may cause mesenchymal cells to be directed towards fibroblasts rather than osteoblasts. Therefore, immediate loading of short implants has a detrimental effect on long-term success. A one-stage intervention versus two-stage surgery does not have a positive effect on the success of short implants [12]. Using short implants, following the two-stage implant placement procedure shows higher success rates [32]. Studies consider that the length of implants subjected to immediate loading should be at least 10mm [33].

Crown/Implant Ratio

The crown/root ratio, especially when using short implants, has been considered as one of the prosthetic factors that may increase the risk of biomechanical complication because of overloading/non-axial loading, ultimately resulting in crestal bone loss [34]. The increase of crown height significantly increases the stress concentration on the prosthetic screw and bone tissue. The increase of crown height significantly increases the level of microstrain of bone tissue under axial and oblique loading [35]. Menchero-Cantalejo et al. [36] stated that the use of implants with roughened surfaces that increase the bone-implant contact surface reduces the negative effect of the implant / crown ratio. It was also mentioned that by increasing the number of implants, biomechanical complications that may occur due to the crown/implant ratio can be avoided [36]. Besides, the researchers recommend that a careful occlusal adjustment for control of masticatory forces in clinical cases involving short implants and higher crowns through a palliative control method [35].

Implant Design

The implant design influences its mechanical behaviour and stress distribution to the bone. The short implants with triangular threads, short external hexagon connection and a flat apical profile demonstrated the least stress distribution [37].

CLINICAL AND RADIOGRAPHIC EVALUATION OF SHORT IMPLANTS

Marginal bone loss is a major concern in the long-term prognosis of dental implants [38]. The use of short implants is an alternative for severely resorbed maxilla and mandibula. Tabrizi et al. [39] made a cohort study to evaluate the loss when variable numbers of short implants were used in the posterior mandible. They were divided into three groups according to the number of short implants: two short implants (first and second molar) to the first group, three short implants (first and second molar and second premolar) to the second group, and four short implants (first and second molar and first molar) to the third group. and second premolars) were placed in the posterior mandible. It has been found that the number of implants in the posterior mandible can be an important factor in marginal bone loss in short implant-supported fixed prostheses. It has also been observed that as

the number of short implants increases, the amount of marginal bone loss decreases. In the meta-analysis study of Srinivasan et al. [19], 25 of 266 short implants placed in the maxilla and 14 of 364 implants placed in the mandible failed, and success rates in the lower and upper jaw were determined to be 94.7% and 98.6%, respectively. According to this meta-analysis [19], it has been stated that implants shorter than 6mm can be a predictable treatment option in terms of success. Considering the failures encountered in the study, implants placed in the mandible were found to be superior.

Dursun et al. [40] divided 15 patients with unilateral resorption of the mandible into treatment groups, with short implants and inferior alveolar nerve lateralization. There was no difference between the two groups following marginal bone loss. In light of these results, Dursun et al. [40] stated that standard-length implant placement with short implant placement or nerve lateralization can be considered as promising alternatives in treatments in the atrophic mandibular posterior region. However, in terms of complication risk, it has been predicted that short implants are more preferable to surgical interventions [40]. In the study conducted by Renouard & Nisand [41], 85 patients received 96 short implant treatments supporting single crown and partial prostheses. Implants with machined or oxidized surfaces were used in the study. The failed implants had a machined surface, while one had an oxidized surface, and failure was more common in low density bones. This study [41] shows that short implants can be considered for cases with severe resorption as an alternative to more complex surgical techniques.

Bahrami [42] placed 2 standard implants in the anterior region of the mandible and 2 short implants in the posterior region in a 61-year-old patient who did not accept surgical intervention and prepared an overdenture prosthesis. During the 2-year follow-up, the patient did not experience any pain or complaints. Researchers recommended the use of short implants also in overdenture due to the patient's satisfaction with the treatment result and the functional aspect; However, they stated that more studies should be done [42].

Malo et al. [43] used two short (7mm-8.5mm) implants anteriorly, standard (10mm-13mm) or long implants (15mm-18mm) posteriorly in 43 patients with total edentulism. They applied the All-On-4 concept. Only 2 patients had 4 short implant losses in the first year. It has been stated that the success rate of short implants is 95.7%-95.1%, 100% for standard implants and 95.2% for long implants. Mechanical complications were presented as prosthesis fracture in 7 patients and abutment screw loss in 6 patients. It has been emphasized that longer studies are required to determine the result of this study [43]. Table 1, shows data of a stratified distribution of the evaluated implants.

CONCLUSION

Short implants can be successfully used to support single and multiple fixed treatments with splints to the adjacent tooth in atrophic posterior, even with increased crown-implant ratios. The use of short implants minimizes stress by eliminating factors that restrict the surgeon's correct three-dimensional positioning of the implant. Short implants are a successful alternative for patients who require adjunctive therapy, such as bone graft, before longer implants are placed. This also provides the advantages that the treatment is less invasive, more cost effective, and less tiring for the patient. Short implants can expand the limits of current implant treatments.

Table 1: Data of a stratified distribution of the evaluated implants.

Study (first author and year)	Type of Study	Implant Type	Place	Follow-up Periods	Number of Implants Placed	Number of Implants Failed
Chou et al. [16]	Finite Element Analysis	5×6mm and 3.5×10.7mm (Bicon,Boston, MA)	Posterior mandible and maxilla	-	-	-
Tabrizi et al. [39]	Prospective study	4×6mm (Osseo Speed surface with Micro-thread; Astra Tech, Molndal, Sweden)	Posterior mandible	36 months	65 implants	-
Dursun et al. [40]	Clinical study	<8mm (OsseoSpeed 4.0 S, Astra Tech Implant System; Dentsply Implants, Molndal, Sweden)	Posterior mandible	12 months	52 implants	-
Renouard & Nisand [41]	Retrospective study	6×8.5mm (Brånemark System®, Nobel Biocare AB, Göteborg, Sweden)	Posterior maxilla	37 months	96 implants	10 implants

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