

## Short implants in clinical practice

Abu-Hussein Muhamad\*, Chlorokostas Georges, Shehadee Ameer,  
Jabareen Ayah, Abdulgani Azzaldeen

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**Abstract:** Over time, progressively shorter implants have been placed such that short implants are now available that are less than 6 mm in length. The viability and high success rates seen with short implants can be explained by osseointegration, the macro geometric design of the implant, as well as physics and the distribution of forces. This paper was aimed to review the stability and survival rate of short implants under functional loads. Numerical and clinical studies were reviewed.

**Keywords:** Short dental implants, sinus augmentation, factors affecting bone regeneration in dental implantology.

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### I. Introduction

Osseointegrated dental implants are an effective alternative in the rehabilitation of partial or total edentulous patients [ 1]. Both the need and increase of using treatments associated with dental implants resulted from the combined effect of several factors, such as: population aging, tooth loss related to age, anatomical consequences of edentulism, unsatisfactory performance of removable dentures, psychological aspects of tooth loss, and advantages of implant-supported dentures [2]. Short dental implant placement is an alternative treatment modality to bone grafting procedures [2]. Moreover, short implants may present results similar to those of longer implants [3]. An implant is considered as short when presenting a length smaller than 10 mm [2]. Accordingly, in clinical situations with little bone availability, short implants are a viable, simple, and predictable alternative [3].



**Fig 1;** Pre-operative radiograph.

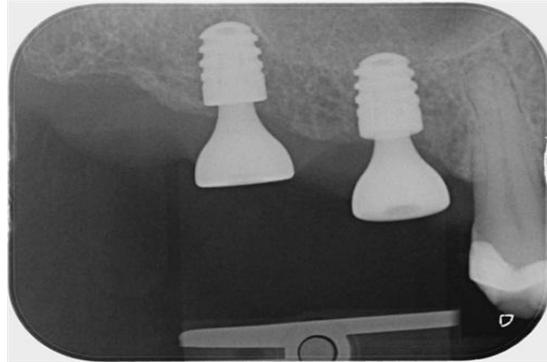


**Fig 2;** Final placement 5.0 X 6.0mm

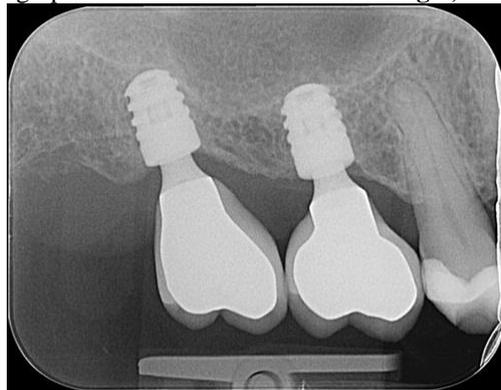
The rehabilitation treatment by implants instituted new concepts of dental prosthesis planning, and this approach provided an efficient masticatory function to patient as well as established aesthetical alternatives [4,5]. Despite this, such rehabilitative strategy demands the possibility of osseointegrated implant placement into the remanent tooth socket and/or basal bone [6]. Otherwise, implant-supported prosthesis planning will be limited, requiring other treatment options to satisfy patient's needs [1,7]. **Fig 1.2**



**Fig 3;** Pre-operative radiograph.



**Fig 4;** Post-operative short implant



**Fig 5;** Two unsplinted molar implant crowns

The pattern of bone losses after tooth extraction at both maxilla's posterior area and mandible is different. Maxilla presents a greater horizontal loss, at buccal-palatal direction, with a slow vertical loss [7]. Maxilla's vertical bone loss occurs in two directions – the natural height remodeling undergone by the bone and maxillary sinus pneumatization [8]. On the other hand, the mandibular vertical bone loss occurs mainly at the vertical direction, generally resulting in a smaller bone height but with reasonable bone amount at the horizontal plane [9,10]. Because of this type of bone loss and the presence of important anatomical areas, the planning of atrophic arches' posterior sites is normally more complex [9]. Previous surgeries for bone volume gain and the use of angulated or short implants have been solutions for the treatment planning in these areas [10,11,12]. The possibilities for patient's rehabilitation in such limiting situations have involved advanced surgical techniques, such as bone grafts, maxillary sinus lifting, which demand high surgical training as well as increase the treatment length and cost [8,10,12,13]. **Fig 3,4,5**

The use of short implants offer, in relation to the regenerative techniques, several advantages: low cost and treatment length, simplicity, and less risk of complications [8,10].

**Indications for short dental implants ;**Short implants can be used in almost all types of replacements whether fixed or removable including:

1. Single and multiple fixed prosthesis in posterior jaw.
2. In the treatment of a severely resorbed edentulous mandible, with four short-length implants used to support an overdenture or six short implants used to support a fixed prosthesis.
3. In edentulous maxilla, two short-length implants are additionally placed in the distal area, together with longer implants in the premaxilla to support a maxillary overdenture or a fixed prosthesis[14,15].

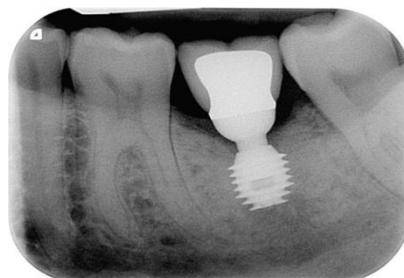


Fig 6; Short round implant for unsplinted second molar

## II. Advantages Of Short Dental Implants

1. Bone grafting to compensate for less height is unnecessary.
2. Less money, pain and time associated with various surgical procedures before placement of implant.
3. Complex surgical techniques are often associated with complications during surgery such as bleeding, perforation of the Schneiderian membrane or nerve injury and post-operatively such as transient or permanent alteration of mandibular sensation, graft and/or membrane exposure, infections and increased peri-implant bone loss. This can be avoided.
4. Osteotomy preparation is simplified since shorter bone preparation is required at the implant site which provides direct access for water irrigation and reduces the possibility of bone overheating.
5. Implant insertion is easier.
6. Angulation to load is improved with short osteotomy site since the basal bone beyond the original alveolar ridge is not always located in the long axis of the missing tooth.[14,15,16,17,18]

This paper was aimed to review the stability and survival rate of short implants under functional loads. Numerical and clinical studies were reviewed.

### □.Anatomical sites of jaw bones

#### A.a.Bone anatomy in the maxilla

Tooth to alveolar relationship in the maxilla, skeletal patterns influence the interpretation of tooth position versus jaw bone position using CT studies. The important anatomical vital organ effect to treatment plan is the maxillary sinus.

Maxillary basal bone relationships: The alveolar bone and basal ridge often diverge from each other. This inappropriateness will influence for socket preservation as the more divergent the alveolus becomes, the thinner the facial alveolar bone and the higher resorption following tooth loss.[19] **Fig 1,2,3,4,5** The maxillary bone quality has been described as less dense when compared with the mandible. They found that the anterior mandible had densest bone, followed by the posterior mandible, anterior maxilla, and posterior maxilla .[20]

#### A.b.Bone anatomy in the mandible

Tooth to alveolar relationship in the mandible: Similar to the maxillary position of mandibular teeth is commonly divergent to the position of the basal bone. The important anatomical vital organ effect to treatment plan is inferior alveolar nerve.[20] **Fig.6**

### □.Biomechanical Considerations

#### B.1.Diagnostic

**a)Implant diameter:** It is more efficient than implant length for dissipation of stresses, because the area receiving maximum effort is the bone crest and very little stress is transferred to the apical portion. An increased length would therefore only improve primary stability but wider implant would not only increase the primary stability but also the functional surface area at the crestal bone level leading to better distribution of occlusal forces. Finite element analysis has also supported this concept and demonstrated that implant length might not be the principal factor influencing transfer of occlusal loads to the bone-implant interface .[21]

**b).Implant design:** The implant surface area can be increased by [20,21,22]:

I. Thread number: More the number of threads per unit length in the same axial plane more is the implant surface area in contact with the bone.

II. Thread depth: Deeper threads provide more implant surface area.

III. Thread shape: The square thread design has a higher bone-implant contact percent as compared to v-shape and reverse buttress thread designs .

IV. Implant surface: As compared to turned smooth surface, rough microtopography of implant surface increases the bone-implant contact surface area and accelerates osseointegration. It also compensates for inadequate crown/implant ratio

**c). Lack of cantilevers:** A cantilever magnifies the forces directly proportional to the height of the crown. It creates six different potential rotation points on the implant body. Eliminating cantilevers favors biomechanics and increased treatment predictability.[20,23]

**d). Number of implants:** Use of multiple implants will increase the functional surface area to resist occlusal forces.[20,24]

**e). Crown/implant ratio:** Increased crown/implant ratio can act as a vertical cantilever leading to crestal bone loss and implant failure. However, improvements of surfaces and implant systems along with proper force orientation and load distribution have allowed high crown/implant ratios to be applied with success.[20,23]

#### B.2. Surgical

a) **Two step surgical protocol:** A two stage surgery is advocated for short implants as it provides good primary stability during healing phase. The time elapsed between the surgical and load stage should be 4-6months for maxilla and 2-4months for mandible [20].

b) **Adapted surgical protocol:** Enhanced initial implant stability can be achieved by eliminating a step in standard surgical protocol such as eliminating the countersink drill or eliminating the final drill in the standard drilling sequence [20,24]. Soft bone drilling protocol should be followed in poor quality bone whereas, the final bone drilling is done with narrow drills rather than standard size drills.[25]

### B.3.Prosthetic

a) **Implant to abutment connection:** Morse taper connection induces less marginal bone loss as compared to external hex abutment connection and also promotes bone growth over the implant shoulder [21]. Internal hex implant abutment connection shows a wider force distribution as compared to external hex connection. [22] Platform switching maintains the crestal bone for the entire length of the implant up to the collar level.

b) **Occlusal table:** Small occlusal table reduces the offset loads on the implant.

c) **Incisal guidance:** Implants should follow a biomechanical approach similar to natural teeth to accommodate the higher bite forces in the posterior regions of the mouth. Incisal guidance of the anterior teeth eliminates lateral forces to the posterior teeth in all mandibular excursions.[20]

d) **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.[20,25]

## III. Use Of Short Implants With Adjunctive Surgical Procedures

To facilitate implant placement in posterior atrophic maxilla, the use of a crestal lift procedure could be a less invasive alternative to the conventional lateral window procedure. While the crestal approach is less invasive, there are some disadvantages associated with it: the amount of bone that can be gained using a crestal approach is less than what can be obtained with the lateral window technique, and a minimal amount of crestal bone height of about 3 mm is required to stabilise the implant at placement [26]. Therefore, in presence of reduced residual bone height, along with crestal sinus lift procedure, placement of short implants have been attempted to reduce the rehabilitation period [ 27]. **Fig.7**

Also, implants installed into alveolar sockets immediately after tooth extraction have been shown to yield predictable outcomes [ 20]. The use of this procedure reduces the number of surgical sessions and may also reduce the time between surgery and prosthetic delivery [28]. For this placement modality the need for implants that are longer than the remaining extraction sockets has been propagated under the assumption that implant stability may be guaranteed in the area beyond the apex of the extraction socket [29]. However, because of the presence of anatomical structures such as the maxillary sinus or the inferior alveolar nerve, bone may not be available beyond the apex of the socket. Therefore various investigators have studied effectiveness of short implants placed in animal models and have found promising results in immediate extraction sockets [30]. **Fig.8**



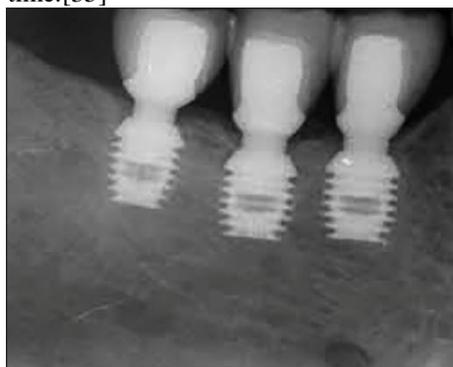
**Fig 7:** failing maxillary short implant used as distal abutment for long span bridge

## IV. Discussion

The use of Short dental implants has been debated over more than two decades now because of their assumed high failure rates when compared to the long implants which promise better long-term results. However, research fails to tell us that prognosis of the Implant is dependent upon the length. [1,3,20]According to Goodacre et al. in 1999 a review of Short dental implants in clinical studies between 1981 and 1997; a higher failure rate with short implants than with long implants was observed. However, recent clinical and biomechanical studies and reviews[3,9,10] show that short implants predictability is comparable to long ones. Over the last decade, Short dental implants have been extensively reviewed, and many factors relevant to success of the implant have been put forward.[31]

Atieh et al. the authors found that short implants may constitute a viable alternative to longer implants, which may often require additional augmentation procedures. [32] In a retrospective study done by Anitua et al results showed that Short dental implants can be considered safe and predictable if used under strict protocols. These protocols include restriction of lateral forces on implant prosthesis, increasing thread pitch and others as mentioned earlier.[33]

In a study carried out by Arlin[34] comparing clinical outcome of short (6-mm and 8-mm) dental implants placed in sites with low bone availability (7-11 mm) the results indicated that the 2-year outcome for 6-mm and 8-mm implants was comparable to that for longer (10-mm to 16-mm) implants in this patient population. The work of Friberg et al. on machined 6 mm and 7 mm long implants, which had longest observational period showed that implant losses occurred prior to or around first few years of loading and no major complications occurred over time.[35]



**Fig 8 :** successfully restored short dental implants in the mandible

Misch et al. published a literature review of failure rates associated with dental implants <10 mm long in the posterior regions of partially edentulous patients undergoing placement from 1991 to 2003. They reported that among the 2837 short implants, the survival rate was 85.3%. It has been suggested that the use of longer implants to provide a larger surface area for stress distribution may not necessarily be appropriate or advantageous.[22]

Hagi et al reported that short implants of 6 and 7 mm length with press-fit shape and sintered porous surface topography demonstrated the best performance, with a lower failure rate.[36] It was concluded that surface geometry plays a major role in performance of dental implants of lengths 7 mm or less. Das Neves et al analyzed the treatment outcome of longitudinal studies using Branemark and compatible implants of 7, 8.5, and 10 mm in length, and based on the results they recommended that short implants could be used as an alternative treatment to advanced bone augmentation surgeries.[19] Telleman et al conducted a systematic review that evaluated the survival rate of short (< 10 mm) implants in partially edentulous patients and concluded that short implants can be successfully used in these patients with better prognosis in the mandible of nonsmokers.[16] A systematic review by Annibali et al evaluated clinical studies which use implants of less than 10 mm length, to determine the success of short implant-supported prosthesis in the atrophic alveolar ridge. They found a higher cumulative survival rate for implants with a rough surface, which leads to the conclusion that the provision of short implants with prostheses in patients with atrophic jaws seems to be a successful treatment modality in the short term; however, more clinical studies are needed to support the long-term assessment.[37]

Kotsovilis et al, who conducted his meta-analysis to answer the question: "Is there a significant difference in survival between short ( $\leq 8$  or  $< 10$  mm) and conventional ( $\geq 10$  mm) roughsurface dental implants placed in totally or partially edentulous patients?" This meta-analysis included 37 articles and concluded that the placement of roughsurface short implants was as effective a treatment modality as long rough-surface implants.[38] The second review, by Romeo et al,[33] concluded that short and standard implants have a similar survival rate. Nevertheless, some important confounders needed to be identified in future studies as they might be contributing factors on the success of short implants.[39] Yang et al. evaluated experimentally the biomechanical performance of seven 7mm short implants in splinted restorations using strain gauges. The implants were splinted together (short-short implant splinted restoration, SS) or individually with a 4.4 X 12.0mm implant (short-long implant splinted restoration, SL), and a 50N oblique load was applied to both restorations. They observed that the strain was significantly decreasing with increasing implant diameter in both the SS and SL restorations, and the observed strain was identical for the splinted implants of the same diameter and those splinted to the long implant. They suggested that splinting of two short implants has the same biomechanical effectiveness as splinting to a single long implant.[40]

Grant et al evaluated the overall success rate of short implants (8 mm in length) placed in the partially or completely edentulous mandible and restored with fixed or removable prostheses. A total of 124 patients were included in the study, with placement of 335 short implants, and the survival rate obtained was 99% in the

mandible. It was concluded that short implants provide a predictable treatment alternative to bone grafting and nerve lateralization for the atrophic mandible.[41]

Esposito et al supported the same conclusion with a randomized control trial that compared 6.3-mm-long implants to longer implants placed in vertically augmented atrophic posterior mandibles, and evaluated if this was a suitable alternative treatment option. The study included 60 partially edentulous patients who were assigned to two groups to receive either 1 to 3 short or longer implants placed in vertically augmented bone. All patients were followed for up to 3 years after loading. Results showed that there were statistically significantly more complications in augmented patients. Short implants experienced statistically significantly less bone loss than long implants. It was concluded that short implants could be a valid alternative to vertical augmentation and provide faster and less expensive treatment with less morbidity.[42]

Pieri et al. evaluated prospectively the clinical and radiographic outcomes of 61 submerged ultrashort implants (4mm diameter, 6mm length) supporting fixed partial dentures in severely atrophic posterior mandibles. The implants were loaded after 5 to 6 months. They recorded a failure of two implants before loading, while the other implants had favourable clinical and radiographic findings throughout the observation period (2-year survival and success rate: 96.8%). Mean changes in marginal bone levels were stable ( $0.40 \pm 0.23$ ,  $0.51 \pm 0.38$ , and  $0.60 \pm 0.13$ mm after 6 months and 1 and 2 years, resp.) and were unaffected by measured crown-to-implant ratios (range: 1.31 to 3.12).[43]

Stellingsma et al compared the clinical and radiographic results of three groups of implant treatment in combination with overdenture prostheses in patients with extremely resorbed mandibles. The three treatment groups were: a transmandibular implant, augmentation of the mandible with an autogenous bone graft and the placement of four implants, and the placement of four implants (8 to 11 mm in length) only. Postoperative complications, implant survival, periodontal indices, change in bone height, and prosthetic complications were assessed during a 10-year evaluation period. After 10 years they found significantly fewer implants were lost in the implant-only group. The cumulative 10-year implant survival rate of the transmandibular implants was 76.3%, and the augmentation group 88%, in comparison with the group provided with short endosseous implants (98.8%). It was concluded that the use of short implants in combination with overdentures in the extremely resorbed mandible seems to be the first choice of treatment because of the low morbidity, high survival rate, and favorable periodontal parameters. In addition, the surgery can be done in an outpatient setting which will reduce the cost of treatment.[44]

Greenstein and Tarnow reported that the guidelines for implant placement include leaving a 2mm safety zone between an implant and the coronal aspect of the nerve.[45] Therefore, the observation of the inferior alveolar nerve and mental foramen on panoramic and periapical films prior to implant placement is essential. Other authors agree with Greenstein to maintain a spatial distance of 2mm or more for safety reasons in three dimensional planning [46].

Few studies used exclusively short implants in maxilla (Fig. 5). Success rates of 94.6% to 100% were reported. [2,6,8,10,11,13] Fuggazzato and co-workers placed 979 implants in molar position, restored them with single crowns and followed them up to 84 months, with a cumulative success rate of 95.1%. These success rates may be attributed to the use of rough surface implants and a better assessment of bone quality, with a change in surgical technique. A study on ultra-short implants (5x5 mm) [48] with success rates of 85.7% for maxilla and 100% for mandible after a functional period of 1 to 8 years may push even further the limits of conservative approaches in implant dentistry. However, long-term controlled studies and bigger sample size are warranted to determine the validity of these results in maxilla.[47]

Early studies indicating good long-term results on short implants, independently of surface characteristics and prosthetic considerations, used preferably the mandible as a primary site versus the maxilla. Tawil and Younan used the mandible in 88.8% of the cases, whereas Deporter and co-workers [25] used it in 100% of the cases.[48] The main reason for indicating short implants in mandible is better mandibular bone quality compared to maxilla. It is also of relevance to note that vertical bone augmentation techniques in mandible are more difficult to achieve and less predictable than in maxilla (lateral approach or osteotome technique sinus lifts). Numerous reports using short implants of different surfaces and macrogeometry confirmed the approach validity in posterior mandible .[50]

Short implants are a much less complex and less invasive treatment than placement of longer implants in clinical sites where prior adjunctive ridge augmentation, localized bone grafting, inferior mandibular nerve repositioning or maxillary sinus elevation would be required. They also result in the removal of less bone than with longer implants and are less invasive compared to these and therefore probably less traumatic.

Short implants simplify treatment in the posterior resorbed maxilla and mandible and reduce the number of situations where adjunctive therapy is required. Even in cases where adjunctive therapy is still required, the degree of invasiveness may be reduced. For instance, Ferrigno et al. concluded following an analysis of 12-year data that the use of short implants together with the less invasive internal sinus lift procedure could reduce the need for the more invasive sinus lifts and bone grafting. Short implants can also be placed if previous bone graft

resorption has occurred at a site intended for longer implants. They also remove the need for cantilevers that might otherwise be required to avoid placing implants in an area with resorbed bone and that are associated with a higher failure rate.[51]

Malo et al. published their prospective study in 2007 on 237 patients who received 408 short (7–8.5 mm) implants (131 7 mm; 227 8.5 mm). Restoration and loading occurred four to six months following implant placement. The cumulative survival rate was found to be 96.2% for 7 mm implants and 97.1% for 8.5 mm implants at five years, with a follow-up period ranging from one to nine years.[52] The use of short implants not only reduces the need for more invasive adjunctive treatment, but also therefore reduces the risk of failure or complications associated with these procedures and removes the risk of complications that could be associated with placement of longer implants in a site where the height or amount of available bone is suboptimal. A further consideration is the more invasive nature of the major adjunctive surgical procedures that may be relatively contraindicated in patients who are otherwise suitable candidates for implant therapy.[1,2,8,10,20]

For the clinician, placement of short implants of a site-appropriate length is substantially less difficult than the placement of longer implants where an adjunctive procedure would also be required. Shorter implants therefore increase the number of cases that can be treated by the general dentist without referral. This enables the general practitioner who is trained and has gained expertise in the placement of endosseous implants to treat the patient and place a short implant without the need for an adjunctive procedure. [1,2,8,10,20]

## V. Conclusion

Short implants are simpler to place in clinical sites with healthy bone, albeit with lower height and volume than required for longer implants. They have been studied in single unit and multiple-unit implant-supported fixed prostheses and overdentures. In recent studies, they have proven to have success and survival rates equivalent to longer implants. This has several implications for the patient and clinician.

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