ISSN 2377-1623
DENTISTRY
OpenJournal
Openventio PUBLISHERS

Mini Review

A Clinical Paradigm and Pertinent Literature Review for Placing Short Implants

Suellan G. Yao, DMD[1]; James B. Fine, DMD[2*]

[1]*Private Practice New York, New York, USA*
[2]*Columbia University College of Dental Medicine, New York, USA*

***Corresponding author**
James B. Fine, DMD
Senior Academic Dean, Professor of Clinical Dentistry, Columbia University College of Dental Medicine, NY, USA; E-mail: jbf1@cumc.columbia.edu

Article information
Received: April 15th, 2021; **Revised:** July 5th, 2021; **Accepted:** July 5th, 2021; **Published:** July 7th, 2021

Cite this article
Yao SG, Fine JB. Clinical paradigm and pertinent literature review for placing short implants. *Dent Open J*. 2021; 7(1): 16-24. doi: 10.17140/DOJ-7-145

ABSTRACT

Placing an implant to replace missing teeth can be challenging because of lack of vertical and/or horizontal bone ridge, maxillary sinus pneumatization and inferior alveolar nerve position. Additional surgical procedures may be necessary, with varying predictability, where vertical augmentation being the least predictable. An alternative option is to place short implants and exclude the additional surgical grafting procedures. By reviewing studies, this paper explores the predictability of the short implants for use in the methods. Bicon SHORT® implants are available in 5 and 6 mm lengths and seem to be able to overcome such limits but more long-term studies are still needed to determine long-term prognosis and success of short implants in terms of them being comparable or equal to longer or standard length implants.

Keywords
Short implants; Bone augmentation; Ridge height; Implant length; Implant width.

INTRODUCTION

Patients lose their teeth for various reasons such as caries, periodontal disease or trauma. When patients are missing a tooth/teeth, they have several options for replacement, such as removable dentures, fixed prostheses and endosteal implants. Which option is best for the patient depends on several factors such as oral anatomy, esthetics and finances. Implants are often appealing to patients because of their ability to closely mimic a natural tooth in terms of appearance and function. However, placing an implant can be challenging because of bone ridge height and/or width, maxillary sinus pneumatization and position of the inferior alveolar nerve, and these may require additional surgical procedures such as maxillary sinus membrane elevation, and bone graft, distraction osteogenesis, guided bone regeneration, onlay bone graft and displacement of the inferior alveolar nerve. With these procedures, there can be additional complications such as infection, sinus membrane perforation, flap dehiscence and post-operative pain.[1] The predictability of success of these procedures is also variable. Vertical bone grafting is the most unpredictable[2] since the patient after the procedure still may not have gained enough bone height to position a standard-size implant.[3] An alternative option is to place a short implant, which may exclude the need for the aforementioned surgical procedures. One such study by Scarano et al[4] showed no complications and predictable rehabilitation of the atrophic posterior mandible with short implants.[4] The purpose of this paper is to explore the predictability of the placement of short implants to replace missing teeth.

MATERIALS AND METHODS

Papers were chosen from those published between 2012 through 2021. Studies needed to include placement of short implants. Additional criteria could include comparison to standard length implants, a range of prosthesis and placement in grafted bone sites.

Studies

Al-Johanny et al[5] tried to propose an implant design based classification system classifying for implant design, length and diameter of implants to try to standardize terminology in the scientific literature. In an attempt to propose a classification scheme, they looked at 1) clinical studies, 2) intervention studies based on implant length and/or diameter, 3) studies that clearly stated the measurements and names of their implants and 4) studies based on the implant systems of some manufacturers which are listed in Table

1. Based on the terms used most frequently, they made a classification with Extra-narrow, Narrow, Standard and Wide in regards to implant diameters and Extra-short, Short, Standard and Long in regards to the implant length as listed in Table 2. The diameter was defined as the width of the implant at the neck area regardless of the diameter of the platform. The length was defined as the measure from the end (base) to the neck of the implant regardless of the length of the platform. The main advantage to this classification is to allow for standardization in communication and research and allows comparisons of study results and methodologies. Limitation of this study is that it was difficult to create a systematic approach to answer the question (replacement of missing teeth) and that animal (*in vitro* studies are far from the aim to set a predictable success rate of short implants compared with the standard length ones, so it's better not to include *in vitro* studies) studies were not included and therefore other implants may also have been overlooked. The authors advice this classification for future studies.

Table 1. *Implant Systems*[5]

• Straumann (Andover, MA, USA)
• Astra Tech (Mölndal, Sweden)
• Nobel Biocare (Kloten, Switzerland)
• XiVE (Mannheim, Germany)
• OsteoCare (Berkshire, UK)
• Camlog (Basel, Switzerland)
• Zimmer (Carlsbad, CA, USA)
• 3MESPE (3M,St.Paul,MN, USA)
• ANKYLOS (Mölndal,Sweden)
• Bicon (Boston, MA, USA)
• BioHorizon (Birmingham,AL, USA)
• IntraLock (Boca Raton, FL,USA)
• MIS (Vienna, Austria)
• BIOMET3i (Carlsbad,CA,USA)

Table 2. *Implant Classification*[5]

Measurements
- Diameter
  - o Extra-narrow: <3 mm
  - o Narrow: ≥3 mm-<3.75 mm
  - o Standard: ≥3.75 mm–<5 mm
  - o Wide: ≥5 mm
- Length
  - o Extrashort: ≤6 mm
  - o Short: >6 mm-<10 mm
  - o Standard: ≥10 mm-<13 mm
  - o Long: ≥13 mm

While there are multiple definitions for which length an implant is qualified as a short implant, for this paper it has been defined as less than 8 mm. Benefits of a short implant are a less invasiveness/more simplicity, shorter surgical time and lower morbidity rates and cost.[6] However, short implants are often associated with high failures rates because of a smaller bone to implant contact and disadvantage in the crown to implant ratio. Studies have been conducted comparing the *in vivo* placement of short implants to the placement of standard length implants with additional surgical grafting procedures.

Jain et al[7] summarized biomechanical considerations broken into 3 categories: 1) diagnostic, 2) surgical and 3) prosthetic. These three categories are further broken down (Table 3). They also included Nisand et al[8] guidelines for placement of short implants and additional surgical procedures based on bone height, bone quality and risk factors, such as smoking, age and periodontal disease. A resorbed mandible of any bone quality with a ridge height <8 mm will need advanced surgical procedures, while a resorbed mandible of any bone qualities with a ridge height ≥8 mm, can receive short implants. For the resorbed maxilla, they recommend a sinus lift procedure where the ridge height is <5 mm and in type IV bone where the ridge height is 5-6 mm. They recommend short implants where the ridge height is ≥6 mm in any bone qualities and where the ridge is 5-6 mm in bone type I, II, III bone. The above mentioned guidelines are applicable in ridges which are wide

Table 3. *Biomechanical Considerations*[7]

1. Diagnostic
   a. Implant diameter–wider implant will increase the primary stability and functional surface area at the crest bone level.
   b. Crown/implant ratio–improvements of surfaces and implant systems allow high crown/implant ratio.
   c. Bone quality–primary factor for short implant success.
   d. Lack of cantilevers–eliminating cantilevers favors biomechanics.
   e. Number of implants–multiple implants will increase functional surface area.
   f. Implant design–surface area can be increase by:
      i. Thread number–more
      ii. Thread depth–deeper
      iii. Thread shape–square has higher bone implant contact
      iv. Implant surface–rough microtopography

2. Surgical
   a. Two step–advocated for short implants because it provides good stability during healing phase.
   b. Adapted surgical protocol–possibly eliminated steps in standard surgical protocol such as countersink or final drill.

3. Prosthetic
   a. Implant to abutment connection–morse taper connection induces less marginal bone loss, internal hex implant abutment connection shows wider force distribution and platform switching maintains crest bone.
   b. Occlusal table–small table reduces offset loads on implant.
   c. Incisal guidance–should be similar to natural teeth.
   d. Splinting–increase functional surface area or support and transmits less force to prosthesis.

enough to place an implant of at least 5 mm in diameter. Their indications for short implants supported prostheses whether fixed or removable were as follows:

1. Single and multiple fixed prosthesis in posterior jaw (mandible).
2. Four short implants for an overdenture or 6 short implants for a fixed prosthesis in the severely resorbed edentulous mandible.
3. Two short distal to longer implants placed in the premaxilla for a maxillary overdenture or fixed prosthesis.

Their conclusions were: short implants can be successful when the biomechanical factors and clinical protocols are taken into account in the pre-operative planning of intervention and prosthesis.

Goncalves et al[9] developed a standard evaluation protocol based on their systematic review of essential parameters required to access the long-term clinical performance of short and extra short implants. Their proposed protocol includes both surgical and prosthetic parameters of the patient and implant, both surgical and prosthetic (Table 4). It is advocated that it will help regiment further investigations and help in the decision making process.

Thoma et al[10] in a narrative review created a decision tree for treatment in the posterior maxilla and mandible based on several parameters such as scientific evidence, operator surgical skill and experience and patient's preference. For the posterior maxilla they recommend the following choice as based on the residual vertical bone height: 1)) in case of 6-8 mm of bone, short dental implant and 2)) in case of >8 mm of bone , standard length implant with transcrestal sinus floor membrane elevation. For the posterior mandible based on vertical bone height: 1) in case of 10 mm, standard-length implant. They feel that short dental implants have a number of advantages for the patient and clinician.

A Short Implant System

A number of studies summarized in Table 5 find that short implants are a favorable option, especially in sites where an additional surgery may be needed to augment the bone prior to placing a standard length implant. However, they also agree that more studies need to be conducted and more long-term results are needed.

Bicon implant system[32] has challenged the concept that short implants are reserved for situations when there is a limited amount of available bone height. Bicon SHORT® implants are short dental implants in 5 mm and 6 mm height. They have a bacterially-sealed, 1.5 degree locking taper abutment to implant

Table 4. *Patient and Implant Parameters*[9]

1. Biological parameters a. Plaque index b. Bleeding index c. Probing depth d. Pain	5. Prosthetic protocols a. Location b. Distance between implants c. Type of prosthesis d. Type of abutments e. Splinted f. Prosthesis material g. Cemented or screwed h. Platform switching i. Cantilever length j. Occlusion
2. Observation a. Parafunction b. Smoking habits c. Diabetes d. Alcoholism e. Osteoporosis f. Radiotherapy in head/neck	6. Radiographic parameters a. Anatomical crown length b. Implant length c. Crown height space d. Resorption e. Bone gain
3. Implant parameters a. Brand b. Length c. Diameter d. Surface treatment e. Shape f. Abutment connection	7. Additional parameters (integrity of prosthesis) a. Major failures: i. Fracture of bridge ii. Fracture of implant iii. Infection iv. Implant mobility or removal v. Before loading vi. After loading b. Minor failures i. Fracture of retention screw ii. Fracture of esthetic veneering iii. Decementation
4. Surgical parameters a. Bone level b. Location c. Bone density d. Insertion torque e. Loading protocol f. Primary stability g. Healing cap (submerged or transmucosal) h. Special surgical technique (mini sinus lift, split crest) i. Biomaterial	

Table 5. *Summary of Studies*

Reference	No. of patients	Grouping	Survival Rates and *p* value
Stellingsma et al[11]	60 edentulous patients total, each group 20 patients	Group 1-transmandibular implant (base plate, 4 implant posts (8, 10 or 12 mm length) and 5 cortical screws) Group 2-4 IMZ apical screws (lengths 13,15 or 18 mm) implants in augmented bone Group 3-4 short (length 8 or 11 mm) Twin Plus IMZ implants	**Cumulative 10 year implant survival rate:** Group 1=76.3%; Group 2=88%; Group 3=98.8% Between Groups 1 and 2- logrank test, p=0.068, not sig Groups 2 and 3–logrank test, p=0.009, sig; Groups 1 and 3–logrank test, p=0.0001, sig **Ten year retreatment rate:** Group 1=30%; Group 2=5%; Group 3=0% Between Groups 1 and 2 and Groups 1 and 3–logrank test, p=0.007, sig Groups 2 and 3–logrank test, p=0.317, not sig
Felice et al[12]	60 partially edentulous patients, each group 30 patients	Short–1 to 3 submerged 6.6 mm long implants Long–1 to 3 submerged 9.6 mm or longer implants in vertically augmented bone 61 total inserted implants (long) and 60 total inserted implants (short)	**Up to 5-years after loading:** Long (n=25): prosthesis failures (patients)=5(5); Implant failures (patients)=5(4); Augmentation procedures=2 Complications (patients)=25(21); Short (n=27): prosthesis failures (patients)=5(5); Implant failures (patients)=5(3) Complications (patients)=6(6) ***p* value:** prosthesis failures=1.00; Implant failures=1.00; Complications <0.0001 Both groups had statistically significant marginal peri-implant bone loss at loading, 1, 3 and 5-years after loading (p<0.001)
Rossi et al[13]	45 patients	60 moderately rough surface implants 30 implants (6 mm long, 4.1 mm diameter)–test 30 implants (10 mm long, 4.1 mm diameter)–control	**Survival rates after 5-years:** 86.7% test; 96.7% control Radiographic bone levels around implants **Median value:** At time of surgery 1.8 mm test; 2.08 mm control; p<0.05 At 5 year follow-up 2.23 mm test; 2.70 mm control; p<0.05
Fan et al[14]	60 patients	**554 implants:** 265 implants, 24 patients in short implant group 289 implants, 36 patients in long implant group	Survival rate p=0.96, not significant Complication rate p=0.02, significant, short group had lower complications compared to long group Surgical time p<0.05, significant, shorter time for short group
Lemos et al[15]	Total of 1269 patients who received a total of 2631 dental implants	1650 standard implants 981 short implants	Implant survival p=0.24, not sig Marginal bone loss p=0.06 not sig Complications p=0.08, not sig Prosthesis failures p=0.92, not sig
Bechara et al[16]	33 patients-short implant (6 mm) group 20 patients-sinus floor elevation (lateral technique)/standard length implant (≥10 mm) group	45 implants inserted in each group	IImplant survival rate at 3 years=100% short, 95% standard p=0.38, not sig Mean ISQ (implant stability quotient) **Values:** At placement=68.2 short, 67.8 standard, p=0.1 At delivery of final restoration=69.5 short, 69.4 standard, p=0.9 After 1-year=71.0 short, 71.5 standard, p=0.1 At 3-years=71.6 short, 72.4 standard, p=0.004, sig **Mean MBL (marginal bone loss):** At 1-year=0.14 mm short, 0.21 standard, p=0.006, sig At 3-years=0.20 mm short, 0.27 standard, p=0.01, sig Surgical time and cost significantly higher in standard group, p<0.0001
Pohl et al[17]	101 patients with partial edentulism in the posterior maxilla and remaining bone height of 5-7 mm	137 implants placed Group short–6 mm length implants, 50 patients, 67 implants Group long-11-15 mm length implants and simultaneous sinus grafting, 51 patients, 70 implants	33 year follow-up – 94 patients with 129 implants Group short–45 patients, 61 implants Group long–49 patients, 68 implants Implant survival rate 100% in both groups Marginal bone level (MBL) changes -0.44 mm short, 0.45 long, p>0.05 MBL implant placement to 3 year follow-up p= 0.974: Group short=-0.44+/-0.56 mm, p=0.000 Group long=-0.43+/-0.58 mm, p=0.000 MBL implants loaded to 3 year follow-up, p=0.110: Group short=-0.1+/-0.54 mm, p=0.636 Group long=-0.25+/-0.58 mm, p=0.004 Probing pocket depth at 3 year follow-up–significantly less short group, p=0.035 **Plaque accumulation:** At 1 year follow-up, p=0.098; At 3 year follow-up, p=0.262 **Bleeding on probing:** At 1 year follow-up, higher number of sites short group, p=0.034 At 3 year follow-up, p=0.380
Esfahrood et al[18]	Review–24 papers out of 253 papers selected		Survival rate of short implants in the posterior edentulous maxilla is high and applying short implants under strict clinical protocols seems to be a safe and predictable technique

Bechara et al[19]	88 implants in 53 patients (33 women, 20 men)	45 implants inserted simultaneously with sinus grafting-control group 45 implants placed without grafting–test group	**ISQ (implant stability quotient):** Initial Sample=68; Control=66.8; Test=69.1; p=0.003 sig Notable increase over time Sample=1.8, p=0.001; Control=4.6, p=0.000 Test=3.2, p=0.000 Marginal bone level (MBL) changes In sample during first year of loading=0.18, p=0.017 Later changes=0.06, p=0.5 Significant difference between first year of loading and later, p=0.000 Significant strong negative correlation between MBL changes during 3-year loading period and implant's diameter, rho=-0.432, p=0.000
Pieri et al[20]	45 partially edentulous patients evaluated after 5-years	22 patients, 51 implants–augmentation group 23 patients, 46 implants–short group	8 surgical complication in augmentation group *vs* none in short group, p=0.003 1 short implant failed before loading and 1 standard length implant failed 4-years after, p=1 8 biological and 2 prosthetic complications in augmentation group *vs* 3 biological and 3 prosthetic complications in short group, p=0.09 and p=1.0, respectively **Mean marginal bone loss:** 1.61+/-1.12 mm augmentation group; 0.68 +/- 0.68 mm short group p=0.0002
Benatto et al[21]	**Case report** 1 patient with 2 failing zygomatic fixtures removed and replaced with 4 short implants	Straumann SLAactive: 4.1x4 mm (2) 4.8x6 mm (1) 3.3x8 mm (1)	Patient had remission of sinusitis episodes and no other signs or symptoms. The extra short implants had excellent stability
Svezia et al[3]	110 patients and 110 implants of 6 or 10 mm length placed Internal hex=60 Conical connection=50	Final group: 105 patients **105 implants:** 6 mm=58 10 mm=47	Success rate after 24-months similar between groups=98.3% (6 mm) *vs* 100% (10 mm), p=0.361 Success rate after 2-years similar between internal hex *vs* conical connection=100% *vs* 97.7%, p=0.233 Statistically significant loss marginal peri-implant bone in both groups=0.38 mm (6 mm) *vs* 0.43 mm (10 mm), p=465 At 24-months, loss marginal peri-implant bone internal hex vs conical connection, p=428; Operator, p=0.875
Cruz et al[6]	11 trials, 420 patients	911 dental implants	Survival rate, p=0.86 Amount of marginal bone loss, p=0.08 Higher rates of bio complications for long implants associated with maxillary sinus aug, p<0.00001 Higher prosthetic complication rate for short implants, p=0.010
Palacios et al[1]		458 short implants, 488 regular implants	Implant failure rate, p>0.05 Mean differences of marginal bone loss, at loading p=0.18 Mean differences of marginal bone loss at 1-year follow-up, significant in short group, p=0.002
Rossi et al[22]	35 consecutive patients	Forty 6 mm modified sandblasted large-grit acid-etched (mod-SLA), soft tissue level implants were installed in the distal segments of 35 consecutive patients	The marginal bone level variation from prosthesis delivering and 10-year follow-up ranged from -2.2 to 0.8 mm. The mean bone loss for implants between the prosthesis delivery and the 2-, 5-, and 10-year follow-up period were -0.4 mm, -0.7 mm, and -0.8 mm, respectively. Statistically significant differences were found between prosthesis delivering and all periods (p<0.001) evaluated as well as between 2 and 5-years (p=0.013) and 5-10-years (p<0.001) Bone level changes in mm (yearly visits) Prosthesis delivery—2 years=-0.4 (0.5) Prosthesis delivery—5 years=-0.7 (0.6) Prosthesis delivery—5 years=-0.6 (0.6) Prosthesis delivery—10 years=-0.8 (0.7) 5 years—10 years=-0.2 (0.4) p<0.05 between prosthesis delivery and the yearly visits.
Papaspyridakos et al[23]	637 short implants placed in 392 patients 653 standard implants were inserted in 383 patients	Short implants ≤6 mm Standard implants >6 mm	Implant survival rate with a follow-up from 1 to 5-years Short implant survival rate ranged from 86.7% to 100%, Standard implant survival rate ranged from 95% to 100% The risk ratio (RR) for short implant failure compared to standard implants was 1.29 (95% CI: 0.67, 2.50, p=0.45) The heterogeneity test did not reach statistical significance (p=0.67) The prosthesis survival rates short implant groups ranged from 90% to 100% longer implant groups ranged from 95% to 100%

Anitua et al[24]	50 patients	75 implants=30 in maxilla, 45 in mandible	Five dental implants failed giving a survival rate of 93.3%. All failures occurred in the mandible giving it a survival rate of 88.9%. All failed implants showed an excessive marginal bone loss (>2 mm).The difference in the survival rate between the mandible and maxilla was not statistically significant (*p*=0.063) There was a statistically significant difference in the number of implants to which the short implant was splinted to. The implants in the mandible were mostly splinted to one implant whereas in the maxilla they were splinted to 2 implants. *p*=0.000
Anitua et al[25]	**Two groups were identified:** Short-short splinted group (SS), when both implants had 6.5 mm lengths Short-long splinted group (SL), when one implant was longer than 6.5 mm.	A total of 48 dental implants were placed in 16 patients to support 24 two-implant fixed prostheses	Follow-up (months) 14±5 **6.5-mm-long implant:** Mesial bone loss (mm) 0.21±0.42 (SS); 0.51±0.88 (SL); *p*=0.949 Distal bone loss (mm) 0.37±0.55 (SS); 0.62±0.74 (SL); *p*=0.417 **Splinting implant:** Mesial bone loss (mm) 0.47±0.58 (SS); 0.36±0.67 (SL); *p*=0.688 Distal bone loss (mm) 0.37±0.55 (SS); 0.94±0.66 (SL); *p*=0.049 There were no statistically significant differences between the two groups regarding implant diameters of the extra-short (6.5 mm long) implants, *p*=0.255. The diameter of the splinted implant was not statistically significant between the two groups, *p*=0.365 Significant differences regarding the lengths of the splinted implants, *p*<0.0001
Shi et al[26]	225 patients 225 implants	3 groups with 75 implants each Group 1-6 mm implants alone Group 2-8 mm implants+osteotome sinus floor elevation (OSFE) Group 3-10 mm implants+OSFE	Implant survival rates Group 1=96%; Groups 2 and 3=100% No significant differences in implant stability quotient (ISQ) values, bleeding on probing (BOP), pocket probing depth (PPD), modified plaque index (mPI) and marginal bone loss (MBL) were found among three groups. Significant higher value of intra-operative discomfort was found in group 6 mm (*p*=0.02).
Amato et al[27]	55 patients	Implants immediately placed and loaded 62 extra short implants (5 and 6 mm) 15 short implants (6.5 mm) 69 standard implants (≥10 mm)	Cumulative survival rates=99.3%; Standard=100% Extra short=98.4%; Short=100% Marginal bone loss (MBL) Extra short=0.35 +/- 0.24 mm, short=0.25+/-0.17 mm *vs* standard=0.92+/-0.26mm, *p*<0.05 Since extra short and short were platform switched, difference resulted in absence (1.36 mm+/-0.19 mm) and in presence (0.48+/-0.32 mm) of platform switching in standard length, *p*<0.05 No difference between implants inserted in healed bone, fresh extraction sockets or with crestal approach sinus floor elevation
Malchiodi et al[28]	41 patients	50 ultra short sintered porous surface (5×5 mm)	Overall success rate=94%; Upper=94.4%; Lower=92.9%; *p*>0.05 No significant correlations between peri-implant bone loss and qualitative and quantitative variables. *p*-values all>0.05 Qualitative variables-sex, diabetes, smoking habit, antagonist dentition, type of prosthesis (splint/no splint), site (upper/lower), site (upper premolar, upper molar, lower premolar, lower molar) Quantitative variables–age, follow-up, anatomical C/I ratio (crown/implant), clinical C/I ratio BL (bone level)
Gašperšič et al[29]	11 patients	In each patient, one 10 mm (n=11) and one or two ultra short 4 mm (n=17) implants One 4 mm implant failed to integrate All patients were restored with splinted metal-ceramic crowns connecting the 4 mm implant to the 10 mm implant	Median (range) implant stability quotient At time of insertion 4 mm-61(14-72); 10 mm-66 (52-78) After 6-months 4 mm-68 (51-79); 10 mm-78 (60-83); *p*<0.05 Median (range) clinical crown/implant ratio 4 mm-2.79 (1-3.66); 10 mm-1.06 (0.85-1.46); *p*<0.05 Six-months after prosthesis rehabilitation, median (range) crestal bone loss 4 mm-0.3 mm (-0.7-1.7 mm); 10 mm-9.5 mm (-0.8-3.5 mm); *p*>0.05
Shi et al[30]	225 patients	225 implants with diameters of 4.1 and 4.8 mm and posterior maxillary residual bone height (RBH) 6-8 mm Group 1-6 mm implants alone Group 2-8 mm implants+osteotome sinus floor elevation (OSFE) Group 3-10 mm implants+OSFE) At the 3-year follow-up, 199 patients (Group 1: 67; Group 2: 62; Group 3: 70) were re-examined	**Implant survival rates:** 91.80% Group 1; 97.08% Group 2; 100.00% Group 3 Implant survival rate in Group 1 was significantly lower than that in Group 3 (*p*=0.029) A multivariate Cox model showed that the short-6-mm implants with wide diameter had a protective effect on implant survival (hazard ratio: 0.59, *p*=0.001) No significant differences in bleeding on probing (BOP%), probing pocket depth (PPD), modified plaque index(mPI), marginal bone loss (MBL) and complication-free survival rate were found among the three groups.

Pardo-Zamora et al[31]	74 patients	**99 implants:** short (7 or 8.5 mm); standard (10, 11.5, 13 or 15 mm) 47 short implants in 33 patients 52 standard implants in 41 patients Short 28 implants were placed in the maxilla 19 were placed in the mandible 44 (93.61%) of these were in the molar and premolar regions Standard implants 33 were placed in the maxilla 19 were placed in the mandible 24 in the anterior region (46.16%) 28 in the posterior region (53.84%)	12 month survival rate is 100% **ISQ measurements made:** on the implant placement (ISQ1); the prosthetic loading (ISQ2) at 12 months follow-up (ISQ3) Mean±SD Δ ISQ2-ISQ1 -0.745±2.192 (short); -0.057±2.796 (standard); p=0.316 Δ ISQ3-ISQ2 0.298±1.876 (short); 0.654±1.781(standard); p=0.336 p-value=0.014 (short), p=0.043 (standard) Marginal Bone Level (MBL) at mesial and distal in both implant groups on the day of surgery (MBL1); implant loading (MBL2) 12-months after loading (MBL3) Mean ±SD Δ MBL2-MBL1 -0.263±0.244 (short); -0.305±0.272 (standard); p=0.324 Δ MBL3-MBL2 -0.184±0.191 (short); -0.412±0.588 (standard); p=0.004 p-value=0.009 (short), p=0.889 (standard) There was no correlation between the increase in ISQ and bone loss/gain in relation to the implants, regardless of their length. A slightly positive correlation was found between the Δ MBL2-MBL1 and Δ MBL2-MBL3 values in the short implants (0.664, p=0.00000037). No correlation was found between the increase in ISQ and bone loss/gain in relation to the implants, regardless of their diameter. A weak correlation in wide diameter implants between Δ ISQ1-ISQ2 and Δ ISQ2-ISQ3 values (cc: 0.539, p=0.000194) and Δ MBL1-MBL2 and Δ MBL2-MBL3 values (cc: 0.467; p=0.0016)

connection and a sub-crestal positioning, sloping shouldered implant with a flattened tapered root form body. They claim that their plateau or fin design offers at least 30% more surface area that other implants of similar size. The 5 or 6 mm implant provides five threads in the bone that is adequate to retain the implant and handle the occlusal forces despite a crown to implant ratio greater than 1:1. The use of short implants allows for a less invasive surgical procedure and less post-operative complications. The placement can be also performed flapless. The osteotomy required for the 5 mm is about 6.5 mm in depth to allow for 1.5 mm sub-crestal placement this can be done with very slow drilling at 40 rpms and no irrigation. This also minimizes the surgical trauma to the site. Although the Bicon implant has threads, it is press fit into the site. It does not require a high-level of primary stability as is needed with screw fit implants. The platform switch design allows for the implant allows for the crestal stability needed with short implants.

The short implant can become the implant of choice regardless of the bone volume and restorative plan.[33] This concept of a shorter implant length will allow for less surgically invasive implant placement in all situations including those requiring vertical sinus augmentation.

Urdaneta et al[34] performed a retrospective cohort study to evaluate 5 mm length implants where the same patients received at least one 5 mm wide hydroxyapatite coated Bicon implant. They found that the survival of ultrashort (5 or 6 mm length) implants were comparable to short (8 mm length) implants over an average of 20-months. These short implants can also be used in guided implant surgery.[35]

DISCUSSION

Many implant companies are now incorporating short implants (8 mm or less) into their product line. Four mm length implants are actually available only from few brands. There is a demand by practitioners and patients for less invasive procedures and a reasonable predictability which seems to have a promising trend. The increased use of short implants in clinical practice will lead to improved surgical techniques and implant designs. The restoration using short implants will increase in number with the awareness that the crown-to-implant ratio does not need to be 1:1 for long term success. Short implants can be used instead of 10 mm implants in areas of adequate bone height with the aim to avoid major bone grafting procedures.

In the randomized clinical trial of Naenni et al[36] a comparison between Straumann 6 mm tissue level implants to same brand 10 mm tissue level implants in non-grafted bone areas over a 5 year period resulted that the 6 mm ones had a 91% survival rate compared to 100% of the 10 mm implants. The authors concluded that the use of 6 mm single implants are a reasonable alternative to implants of standard length because of a minor difference in survival rate. To complement, Scarano et al[4] analysed 63 short implants placed inpremolar and molar region of the posterior mandible. All short implants were splinted to at least one other implant. The short implants were machine collared and characterized by 2 portions implant screw and transmucosal collar tissue level, connected to a titanium abutment by a chemical cement seal. The short implants had a survival rate of 98.5% as compared to 97.4% for standard implants. There was no statistical difference of bone loss between the short and standard implants (p=0.1). They concluded that short implants can be used to predictably restore the posterior mandible and avoid the additional surgical procedures in resorbed sites when splinted to a standard implant or another short implant.

CONCLUSION

Clinicians should have short implants as an option for patients. Patients who cannot receive a standard sized implant may be a candidate for a short implant. Short implants may allow patients with unfavorable sites to receive a functional implant without additional surgeries that can lead to complications. However, while this may be a viable option, clinicians should be aware that more studies are needed to determine long-term prognosis and predictability of success of short implants and how they compare to standard sized implants. Additional studies should compare short implants to zygomatic implants, should compare different jaw sites (mandible *vs.* maxilla, anterior *vs* posterior) and compare single unit *vs.* multi-unit prosthesis with short implants. But as more short implants are being placed, there will be more long-term (more than 5-years) data to evaluate short implants and their function.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1. Palacios JAV, Garcia JJ, Caramês JMM, Quirynen M, da Silva Marques DN. Short implants versus bone grafting and standard-length implants placement: A systematic review. *Clin Oral Invest*. 2018; 22: 69-80. doi: 10.1007/s00784-017-2205-0

2. Hameed MH, Gul M, Ghafoor R, Khan FR. Vertical ridge gain with various bone augmentation techniques: A systematic review and meta-analysis. *J Prosthodont*. 2019; 28(4): 421-427. doi: 10.1111/jopr.13028

3. Svezia L and Casotto F. Short dental implants (6 mm) versus standard dental implants (10 mm) supporting single crowns in the posterior maxilla and/or mandible: 2-year results from a prospective cohort comparative trial. *J Oral Maxillofac Res*. 2018; 9(3): e4. doi: 10.5037/jomr.2018.9304

4. Scarano A, Mortellaro C, Brucoli M, Lucchina AG, Assenza B, Lorusso F. Short implants: analysis of 69 implants loaded in mandible compared with longer implants. *J Craniofac Surg*. 2018; 29: 2272-2276. doi: 10.1097/SCS.0000000000004518

5. Al-Johany SS, Al Amri MD, Alsaeed S, Alalola B. Dental implant length and diameter: A proposed classification scheme. *J Prosthodont*. 2017; 26: 252-260. doi: 10.1111/jopr.12517

6. Cruz RS, Lemos CAdA, Batista VEdS, Gomes JMdL, Pellizzer EP, Verri FR. Short implants versus longer implants with maxillary sinus lift. A systematic review and meta-analysis. *Braz Oral Res*. 2018; 32: e86. doi: 10.1590/1807-3107bor-2018.vol32.0086

7. Jain N, Gulati M, Garg M, Pathak C. Short implants: new horizon in implant dentistry. *J Clin Diagn Res*. 2016; 10(9): ZE14-ZE17. doi: 10.7860/JCDR/2016/21838.8550

8. Nisand D, Renourd F. Short implant in limited bone volume. *Periodontol 2000*. 2014; 66: 72-96. doi: 10.1111/prd.12053

9. Goncalves TMSV, Bortolini S, Martinolli M, Alfenas BFM, Peruzzo DC, Natali A, et al. Long-term short implants performance: systematic review and meta-analysis of the essential assessment parameters. *Braz Dent J*. 2015; 26(4): 325-336. doi: 10.1590/0103-6440201300265

10. Thoma DS, Cha J-K, Jung U-W. Treatment concepts for the posterior maxilla and mandible: Short implants versus long implants in augmented bone. *J Periodontal Implant Sci*. 2017; 47(1): 2-12. doi: 10.5051/jpis.2017.47.1.2

11. Stellingsma K, Raghoebar GM, Visser A, Vissink R, Meijer HJA. The extremely resorbed mandible 10-year results of a randomized controlled trial on 3 treatment strategies. *Clin Oral Impl Res*. 2014; 25: 926-932. doi: 10.1111/clr.12184

12. Felice P, Cannizzaro G, Barausse C, Pistilli R, Esposito M. Short implants versus longer implants in vertically augmented posterior mandibles: A randomized controlled trial with 5-year after loading follow-up. *Eur J Oral Implantol*. 2014; 7(4): 359-369.

13. Rossi F, Botticelli D, Cesaretti G, De Santis E, Storelli S, Lang NP. Use of short implants (6 mm) in a single-tooth replacement: a 5-year follow-up prospective randomized controlled multicenter clinic study. *Clin Oral Impl Res*. 2016; 27: 458-464. doi: 10.1111/clr.12564

14. Fan T, Li Y, Deng W-W, Wu T, Zhang W. Short implants (5 to 8 mm) versus longer implants (>8 mm) with sinus lifting in atrophic posterior maxilla: A meta-analysis of RCTs. *Clin Implant Dent Relat Res*. 2017; 19: 207-215. doi: 10.1111/cid.12432

15. Lemos CAA, Ferro-Alves ML, Okamoto R, Mendonca MR, Pellizzer EP. Short dental implants versus standard dental implants placed in the posterior jaws: A systematic review and meta-analysis. *J Dent*. 2016; 46: 8-17. doi: 10.1016/j.jdent.2016.01.005

16. Bechara S, Kubilius R, Veronesi G, Pires JT, Shibli JA, Mangano FG. Short (6 mm) dental implants versus sinus floor elevation and placement of longer (≥10 mm) dental implants: A randomized controlled trial with a 3-year follow-up. *Clin Oral Impl Res*. 2017; 28: 1097-1107. doi: 10.1111/clr.12923

17. Pohl V, Thoma DS, Sporniak-Tutak K, Garcia-Garcia A, Taylor TD, Haas R, et al. Short dental implants (6 mm) versus long dental implants (11-15 mm) in combination with sinus floor elevation procedures; 3-year results from a multicenter, randomized, controlled clinical trial. *J Clin Periodontol*. 2017; 44: 438-445. doi: 10.1111/jcpe.12694

18. Esfahrood ZR, Ahmadi L, Karami E, Asghari S. Short dental implants in the posterior maxilla: A review of the literature. *J Korean Assoc Oral Maxillofac Surg*. 2017; 43: 70-76. doi: 10.5125/jkaoms.2017.43.2.70

19. Bechara S, Nimčenko T, Kubilius R. The efficacy of short (6 mm) dental implants with a novel thread design. *Stomatologija*. 2017; 19(2): 55-63.

20. Pieri F, Forlievesi C, Caselli E, Corinaldesi G. Short implants (6 mm) vs. vertical bone augmentation and standard-length implants (≥9 mm) in atrophic posterior mandibles: A 5-year retrospective study. *Int J Oral Maxillofac Surg*. 2017; 46: 1607-1614. doi: 10.1016/j.ijom.2017.07.005

21. Benatto GB, de Souza Bueno CR, Curvêllo VP, Filho HN. Management of zygomatic fixture complication case using extra-short implants. *J Craniofac Surg*. 2017; 28(8): e797-e799. doi: 10.1097/SCS.0000000000004171

22. Rossi F, Lang NP, Ricci E, Ferraioli L, Baldi N, Botticelli D. Long-term follow-up of single crowns supported by short, moderately rough implants – a prospective 10-year cohort study. *Clin Oral Impl Res*. 2018; 29: 1212-1219. doi: 10.1111/clr.13386

23. Papaspyridakos P, De Souza A, Vazouras K, Gholami H, Pagni S, Weber HP. Survival rates of short dental implants (≤6 mm) compared with implants longer than 6 mm in posterior jaw areas: A meta-analysis. *Clin Oral Implants Res*. 2018; 29 Suppl 16: 8-20. doi: 10.1111/clr.13289

24. Anitua E, Alkhraisat MH. 15-year follow-up of short dental implants placed in the partially edentulous patient: Mandible vs maxilla. *Ann Anat*. 2019; 222: 88-93. doi: 10.1016/j.aanat.2018.11.003

25. Anitua E, Flores C, Flores J, Alkhraisat MH. Clinical effectiveness of 6.5-mm-long implants to support two-implant fixed prostheses in premolar-molar region: the influence of immediate loading and the length of splinting implant. *J Prosthodont*. 2019; 28: e688-e693. doi: 10.1111/jopr.12761

26. Shi J-Y, Li Y, Qiao S-C, Gu Y-X, Xiong Y-Y, Lai H-C. Short versus longer implants with osteotome sinus floor elevation for moderately atrophic posterior maxillae: A 1-year randomized clinical trial. *J Clin Periodontol*. 2019; 46(8): 855-862. doi: 10.1111/jcpe.13147

27. Amato F, Polara G, Spedicato GA. Immediate loading of fixed partial dental prostheses on extra-short and short implants in patients with severe atrophy of the posterior maxilla and mandible: A up-to-4-year clinical study. *Int J Oral Maxillofac Implants*. 2020; 35: 607-615. doi: 10.11607/jomi.7943

28. Malchiodi L, Ricciardi G, Salandini A, Caricasulo R, Cucchi A, Ghensi P. Influence of crown-implant ratio on implant success rate of ultra-short dental implants: Results of a 8- to 10-year retrospective study. *Clin Oral Investig*. 2020; 24(9): 3213-3222. doi: 10.1007/s00784-020-03195-7

29. Gašperšič R, Dard M, Linder S, Oblak Č. The use of 4-mm implants splinted to 10-mm implants for replacement of multiple missing teeth in the posterior maxilla region with expanded maxillary sinus. An observational cases series: patient characteristics and preliminary results. *Int J Periodontics Restorative Dent*. 2021; 41(2): 261-268. doi: 10.11607/prd.4389

30. Shi J-Y, Lai Y-R, Qian S-J, Qiao S-C, Tonetti MS, Lai H-C. Clinical, radiographic and economic evaluation of short-6-mm implants and longer implants combined with osteotome sinus floor elevation in moderately atrophic maxillae: A 3-year randomized clinical trial. *J Clin Periodontol*. 2021; 48(5): 695-704. doi: 10.1111/jcpe.13444

31. Pardo-Zamora G, Ortiz-Ruíz AJ, Camacho-Alonso F, Martínez-Marco JF, Molina-González JM, Piqué-Clusella N, et al. Short dental implants (≤8.5 mm) versus standard dental implants (≥10 mm): A one-year post-loading prospective observational study. *Int J Environ Res Public Health*. 2021; 18(11): 5683. doi: 10.3390/ijerph18115683

32. Bicon Dental Implants. Since 1985 » Simple. Predictable. Profitable. Web site. www.Bicon.com. Accesses April 14, 2021.

33. Vetromilla BM, Mazzetti T, Pereira-Cenci T. Short versus standard implants associated with sinus floor elevation: An umbrella review of meta-analyses of multiple outcomes. *J Prosthet Dent*. 2020; S0022-3913(20)30429-7. doi: 10.1016/j.prosdent.2020.08.002

34. Urdaneta RA, Daher S, Leary J, Emanuel KM, Chaung S-K. The survival of ultrashort locking-taper implants. *Int J Oral Maxillofac Implants*. 2012; 27(3): 644-654.

35. D'haese J, Ackhurst J, Wismeijer D, De Bruyn H, Tahmaseb A. Current state of the art of computer-guided implant surgery. *Periodontol 2000*. 2017; 73(1): 121-133. doi: 10.1111/prd.12175

36. Naenni N, Sahrmann P, Schmidlin PR, Attin T, Wiedemeier DB, Sapata V, et al. Five-year survival of short single-tooth implants (6 mm): Arandomized controlled clinical trial. *J Dent Res*. 2018; 97(8): 887-892. doi: 10.1177/0022034518758036