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CLINICAL RESEARCH

Clinical evaluation of single 4-mm implants in the posterior mandible: A 3-year follow-up pilot study

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ABSTRACT

Statement of problem. Extra-short implants in the posterior mandible can increase the functional surface area and reduce the risk of implant overload. However, reports of treatment using single extra-short implants in the posterior mandible with a midterm follow-up are lacking.

Purpose. The purpose of this prospective pilot study was to evaluate the clinical behavior of single extra-short 4-mm implants placed in the posterior mandible during a follow-up of 3 years from implant restoration.

Material and methods. A total of 18 participants with a single extra-short 4-mm-long implant placed in the area of the mandibular first molars participated in this pilot study. The survival and success rates of implants, as well as biologic and prosthetic variables, were evaluated during a follow-up of 3 years from implant restoration.

Results. The survival rate of the implants was 100%, with no implant or biologic complications recorded. One prosthetic complication (loosening of 1 screw) was observed.

Conclusions. Single extra-short (4 mm) implants in the posterior mandible showed favorable clinical behavior during the first 3-years of follow-up. (J Prosthet Dent 2022;127:80-5)

Implant-supported restorations are a popular prosthetic option, especially for individuals older than 55 years of age.[1] Considering the growth of the geriatric population,[2] the indications for dental implants will continue to increase. Unfortunately, not all potential patients have sufficient available bone height for conventional implant placement after bone resorption and the location of anatomic structures[3] including the inferior alveolar nerve in the mandible and maxillary sinus in the maxilla. For such patients, the clinician generally has 2 treatment options: vertical bone augmentation or the use of short implants.

Bone augmentation procedures are technically more demanding than the placement of short implants[4,5] and are associated with increased postoperative morbidity, complications, treatment time, and number of surgeries.[6-11] Therefore, short implants can be a more straightforward, less expensive, and more rapid alternative, with lower associated morbidity. Success rate has been reported to be similar.[12-19]

The development of increasingly shorter implants has been possible because of the continuous improvements in the implant connection and surface.[20] Outcomes have been assessed with different biomechanical[21] and clinical tests,[22] although clinically, the use of short implants requires more operator experience because adequate primary stability is essential.[23,24] Al-Johany et al[25] proposed a classification for short implants as >6 mm and <10 mm and for extra-short implants as <6 mm.

The clinical success of single short implants has been well documented.[14,26,27] However, when providing extra-short implants, some authors have recommended the use of 2 or more rigidly splinted implants,[28-30] especially in the posterior region, to increase the functional surface area and reducing the risk of implant overload.[31,32] A

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Clinical Implications

Treatment with 4-mm single implants in patients who had lost a posterior mandibular molar showed favorable biologic and prosthetic behavior during the first 3 years.

recent 18-month follow-up study by Nizam et al[33] reported the use of single extra-short implants (4 mm and 6 mm) in the posterior maxilla with and without a sinus lift procedure, with a clinical success rate of 96.3%, comparable with short implants (8 to 10 mm). However, midterm follow-up studies of clinical treatment with a single 4-mm extra-short implant in the posterior mandible are lacking. Therefore, the purpose of this pilot prospective clinical study was to evaluate the behavior of single extra-short 4-mm implants placed in the posterior mandible during a follow-up of 3 years from implant restoration. The null hypothesis was that the use of single extra-short 4-mm implants placed in the posterior mandible is associated with similar implant survival and biologic and prosthetic complications as conventional treatment.

MATERIAL AND METHODS

Thirty participants (18 women and 12 men) who had lost a posterior mandibular molar and presented with a resorbed edentulous ridge were selected and invited to participate in this prospective pilot study. All participants were informed of the aims and risks of the study and signed a written informed consent. The study was approved by the Servicio Salud Metropolitano Oriente Ethics Committee and conducted as per the Declaration of Helsinki. Medical history and anamnesis were recorded, and a cone beam computed tomography (CBCT) scan was made for each participant (Fig. 1A). Subsequently, a regular diameter 4.1-mm extra-short implant (tissue level; Institut Straumann AG) (Fig. 1B) was planned for the mandibular molar region following the surgical drill guidelines provided by the manufacturer.

The inclusion criteria were adults; absence of a maximum 2 mandibular molars; occlusal stability; an antagonist tooth; resorbed posterior mandibular edentulous ridge with a minimum available bone height and width of 5 mm, allowing implant placement with a safety margin of 1 to 1.5 mm from the inferior alveolar nerve; no history of bone augmentation; and absence of systemic diseases that contraindicated treatment with an implant-supported prosthesis. The exclusion criteria were history of radiation therapy; heavy smoking; untreated periodontal disease; parafunctional habits such as bruxism; patients who elected bone reconstruction before implants; and previous history of implant failure in the region of interest.

All 30 participants had an ideal or minimally compromised occlusion, although 27 had lost 2 mandibular molars (class III[34]) and 3 had only lost 1 mandibular molar (class I[34]). Only the first molar was replaced in participants who had lost both the mandibular first and second molars. A single operator (Y.L.) performed the implant surgeries under local infiltrative anesthesia. A full-thickness mucoperiosteal flap was elevated to visualize the surgical site. The insertion torque was measured with a manual torque ratchet (Institut Straumann AG), whereas the implant stability quotient (ISQ) was measured in the mesiodistal and buccolingual directions with a device (Osstell ISQ; W&H Dentalwerk Bürmoos GmbH). A periapical radiograph was made for each participant. After 2 months (Fig. 1C), osseointegration was evaluated by using the ISQ measurement, and healing caps (tissue-level sterile RN healing cap; Institut Straumann AG) were connected to implants. Monolithic zirconia (IPS e.max ZirCAD; Ivoclar Vivadent AG) single-screw definitive restorations over a Ti-base abutment (RN Variobase; Institut Straumann AG) were placed in functional occlusion. Once the rehabilitation phase was completed, a radiograph was made for each participant (Fig. 1D). Follow-up visits were scheduled every 3 months from implant restoration with the same single operator (E.B.) during the first year with their respective periapical radiographs (Fig. 2A). The participants then returned for evaluation every 6 months for the first 36 months (Fig. 2B-D).

During the first year, 12 participants were lost to follow-up. However, no participants were lost to follow-up during the second and third years. Of the 18 participants (11 women and 7 men) who returned in 3 years of follow-up, 17 were of Class III (Fig. 3A, 3B) and 1 was of Class I (Fig. 3C), as per the classification system for partial edentulism.[34]

The survival and success rate of implants as well as the biologic and prosthetic variables were assessed. The implant success criteria included the absence of spontaneous pain under percussion; bone level as per biologic width formation; absence of peri-implant radiolucency; absence of obvious mobility; and dull sound on percussion. The biologic success criteria used were the absence of inflammatory signs or symptoms of peri-implant soft tissue and peri-implant exudates, whereas the prosthetic success criteria included no fracture of the prosthetic abutment or loosening of the attachment screw.

RESULTS

All the 18 extra-short implants evaluated osseointegrated successfully, giving a survival rate of 100%, with no implant or biologic complications recorded. One prosthetic complication (loosening of 1 attachment screw) was observed, which was resolved immediately (Table 1).

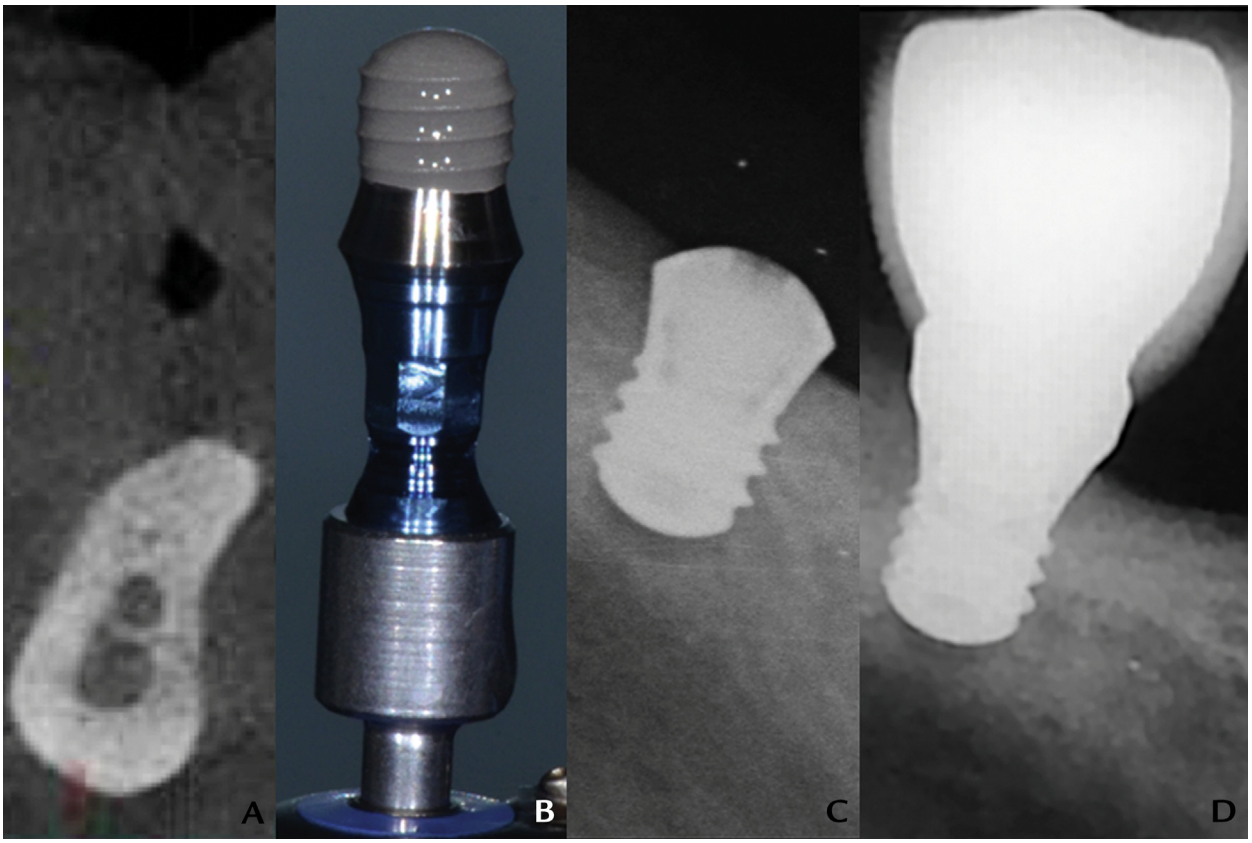

Figure 1. Initial situation and subsequent follow-up visits. A, Bone remnant available. B, Regular diameter 4.1-mm extra-short implant. C, Radiograph after osseointegration. D, Radiograph after definitive restoration (baseline).

All implants achieved primary stability with a mean ISQ value of 63.2. The mean torque was 45 Ncm, whereas the minimum torque achieved was 35 Ncm in 2 participants.

DISCUSSION

The null hypothesis that the use of single extra-short 4-mm implants placed in the posterior mandible would be associated with similar implant survival and biologic and prosthetic complications as conventional treatment was accepted. The 100% survival and success rate of implants during the assessed period may be associated with the strict surgical protocol in conjunction with careful patient selection. In spite of most of the participants missing both the mandibular first and second molars, with only the first molar being replaced, all participants had a minimally compromised occlusion, which may be a critical factor in maintaining long-term implant success.[32]

All implants reached at least 35 Ncm of insertion torque, important because primary stability has been reported to be a critical factor in using extra-short implants successfully.[23] Alonso et al[24] reported an ISQ of 71 in 39 6-mm implants, 77.8% of which achieved a torque >35 Ncm, whereas in the present study, the means were 63.2 for ISQ and 45 Ncm of torque. In addition, no biologic complications were identified, and only 1 prosthetic complication, attachment screw loosening (the most common complication that is straightforward to address), was reported.[3,27]

The risks of using short and extra-short implants, particularly with a single prosthesis are unclear. Villarinho et al[3] considered 6-mm-long implants in a single prosthesis as a procedure with a high risk of failure and recommended splinting for improved stress distribution of occlusal forces. Furthermore, other researchers[4,27] have reported a higher failure rate in single short implants. Papaspyridakos et al[7] demonstrated in a meta-analysis that short implants had a higher risk of failure compared with longer implants. However, some authors[5,22,26] who support the use of short implants and a single prosthesis argue that there is no relationship between the crown/implant ratio and possible failures and bone loss in single implants.

Svezia and Casotto[13] compared 6-mm and 10-mm implants in unsplinted prostheses in the posterior maxilla and mandible over 2 years, observing similar results regarding failure and marginal bone loss between the groups. There is sufficient evidence to support minor differences in the survival rate between standard and short implants, with a success rate of more than 91%.[14-18]

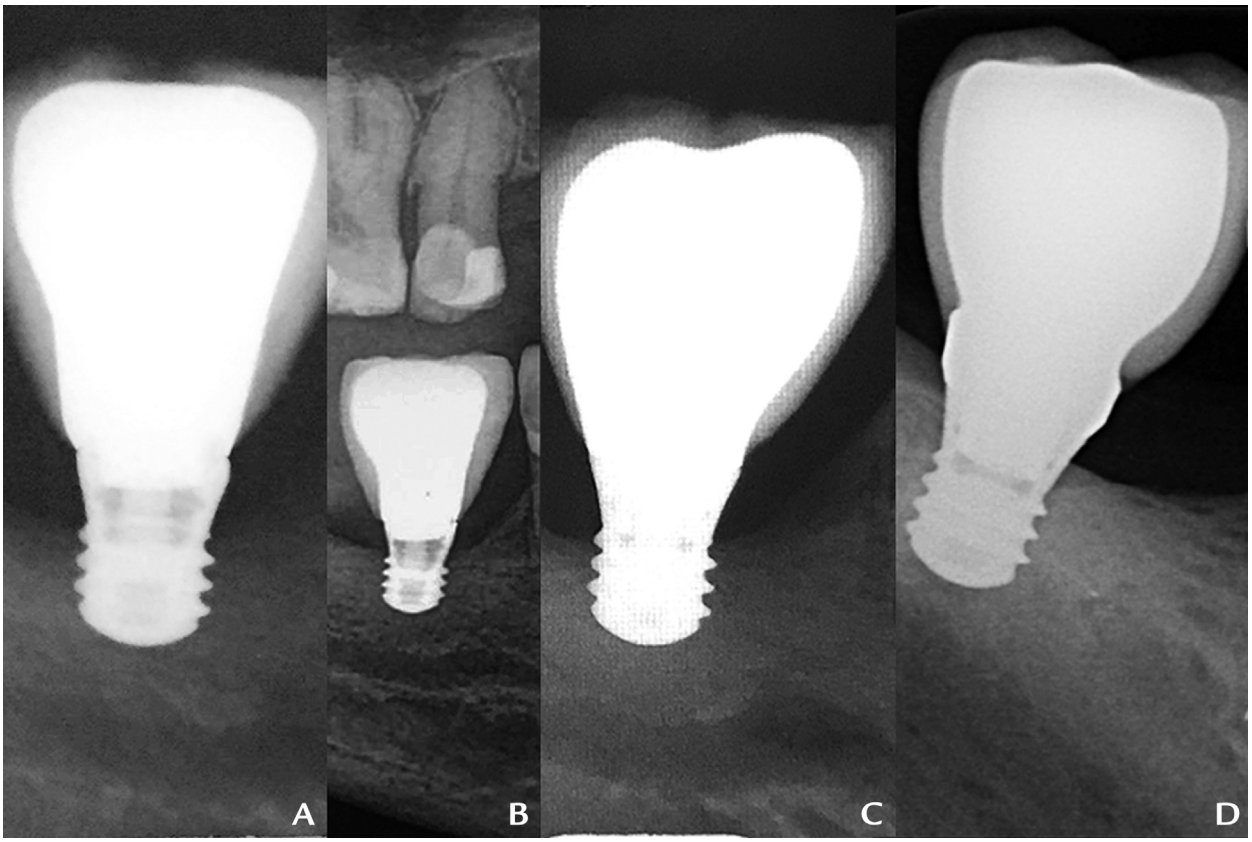

Figure 2. Radiographs at follow-up visits. A, 1 year. B, 2 years. C, D, 3 years

Tolentino da Rosa de Souza et al[14] recommended the use of unsplinted short implants in the posterior region, while Nizam et al[33] reported the use of unsplinted extra-short implants (4 mm and 6 mm) in the posterior maxilla, reporting a clinical success of 96.3% comparable with short implants (8 to 10 mm). The use of single crowns with extra-short implants may be a feasible alternative to that demonstrated in the present study. Furthermore, Mezzomo et al[27] reported that most implant failures occur before prosthesis installation, with no major complications over time.

Extra-short implants (<6 mm) have advantages. Pierrisnard et al,[21] in a finite element study, reported that implants subjected to an oblique load showed concentrated stresses in the first 7 mm. However, the continuous improvements in the implant materials, connection,[20] and surface[31] have increased the resistance of implants to the loads and allowed the design of extra-short implants (<6 mm) with favorable clinical behavior.

Short and extra-short implants were developed as an alternative for patients with insufficient available bone height for conventional implant placement and provide a more straightforward, less expensive, and more rapid treatment option, with lower associated morbidity compared with bone augmentation procedures.[8-11] The present pilot study treated selected participants for whom a more conservative approach was determined owing to anatomic limitations and who declined bone augmentation procedures before implant placement.

Limitations of the present pilot study included the small number of participants, limiting the power of the study, and that the marginal bone levels were not specifically measured; however, the main purpose of this pilot study was to provide preliminary data about the behavior of single restorations in 4-mm extra-short implants in the posterior mandible with a follow-up of 3 years. Ravida et al[19] in a meta-analysis reported that most studies had short follow-up periods ranging from 1 to 3 years, with only a few reporting more than 5 years. Clinical studies with longer follow-up periods are needed to determine the performance of extra-short implants.

The authors are unaware of a previous study evaluating the clinical behavior of single extra-short 4-mm implants with a midterm follow-up in the posterior mandible. Even shorter implants will be difficult for the manufacturers to design, considering biomechanical behavior and potential marginal bone resorption over time. In this regard, a new phase of less invasive implantology avoiding the expensive, challenging, less predictable, and traumatic bone augmentation procedures is required while considering strict patient selection and, whenever possible, careful monitoring.

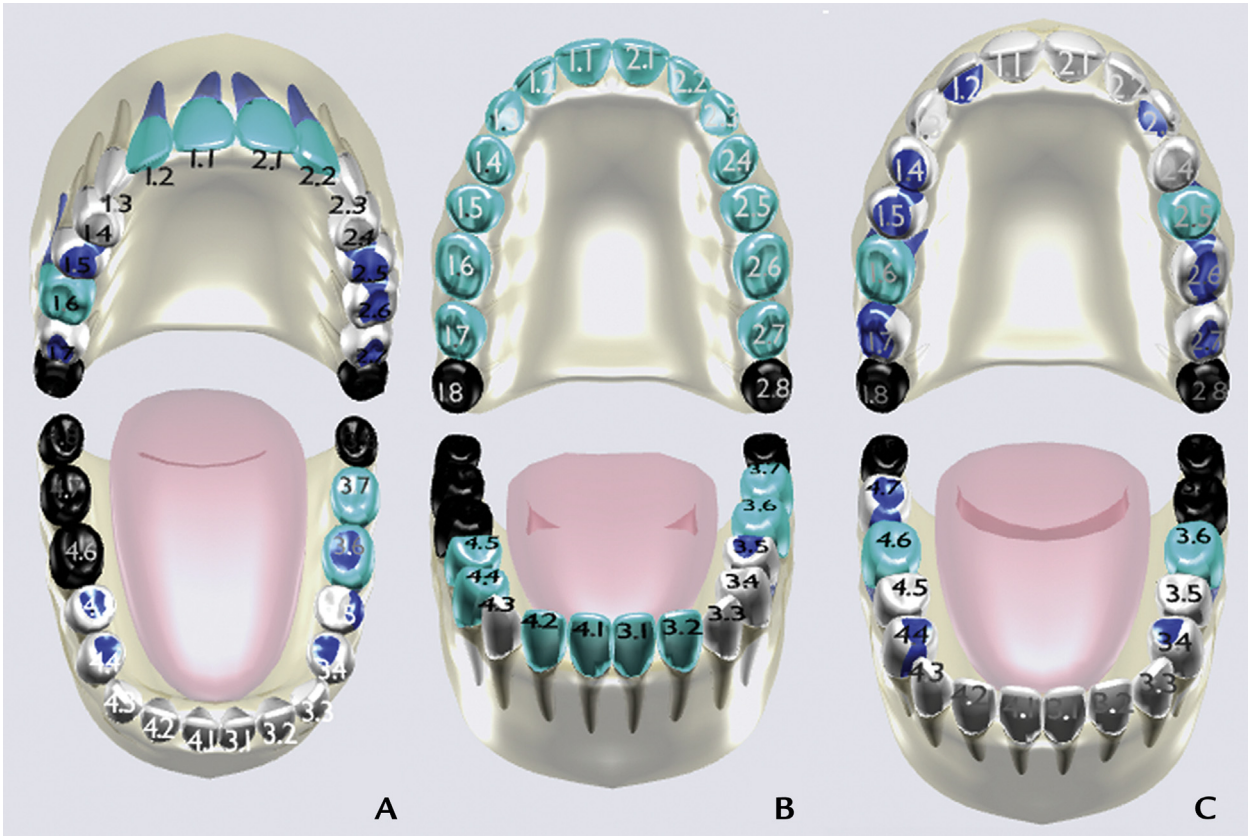

Figure 3. Level of dentition and edentulism summarized in 3D odontograms of selected participants (*black*: absent; *white*: sound; *blue*: composite resin restoration; *light-green*: crown). A, B, Absence of 2 mandibular molars (Class III). C, Absence of 1 mandibular molar (Class I).

Table 1. Summary of surgical, biologic, and prosthetic variables evaluated

				Biologic Complications		Prosthetic Complications	
Participants	**Tooth**	**Torque (N)**	**ISQ**	**Mucositis**	**Peri-Implantitis**	**Screw Loosening**	**Fracture Abutment**
1	1R	50	67	No	No	No	No
2	1R	50	62	No	No	No	No
3	2L	40	69	No	No	No	No
4	1R	45	61	No	No	No	No
5	1R	50	63	No	No	No	No
6	1R	40	61	No	No	1	No
7	1L	35	59	No	No	No	No
8	1R	50	63	No	No	No	No
9	1L	40	65	No	No	No	No
10	1L	50	61	No	No	No	No
11	1L	50	61	No	No	No	No
12	1L	35	57	No	No	No	No
13	1L	50	67	No	No	No	No
14	1L	50	61	No	No	No	No
15	1L	45	65	No	No	No	No
16	1R	50	60	No	No	No	No
17	1L	40	67	No	No	No	No
18	1R	50	62	No	No	No	No
Mean	–	45.5	63.2	–	–	–	–

1L, Left first molar; 2L, Left second molar; 1R, Right first molar; ISQ, Implant stability quotient.

CONCLUSIONS

Based on the findings of this pilot clinical study, the following conclusions were drawn:

1. Single short (4 mm) implants in the posterior mandible showed favorable clinical behavior during the first 3 years of follow-up.
2. These results should be interpreted with caution because long-term follow-up studies (>3 years) and larger sample sizes are needed.
3. Specific patient selection criteria should be considered for this type of treatment to improve the long-term clinical success.

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