REVIEW ARTICLE

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Short dental implants in the posterior maxilla: a review of the literature

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Abstract (J Korean Assoc Oral Maxillofac Surg 2017;43:70-76)

The purpose of this study was to perform a literature review of short implants in the posterior maxilla and to assess the influence of different factors on implant success rate. A comprehensive search was conducted to retrieve articles published from 2004 to 2015 using short dental implants with lengths less than 10 mm in the posterior maxilla with at least one year of follow-up. Twenty-four of 253 papers were selected, reviewed, and produced the following results. (1) The initial survival rate of short implants in the posterior maxilla was not related to implant width, surface, or design; however, the cumulative success rate of rough-surface short implants was higher than that of machined-surface implants especially in performance of edentulous dental implants of length <7 mm. (2) While bone augmentation can be used for rehabilitation of the atrophic posterior maxilla, short dental implants may be an alternative approach with fewer biological complications. (3) The increased crown-to-implant (C/I) ratio and occlusal table (OT) values in short dental implants with favorable occlusal loading do not seem to cause peri-implant bone loss. Higher C/I ratio does not produce any negative influence on implant success. (4) Some approaches that decrease the stress in posterior short implants use an implant designed to increase bone-implant contact surface area, providing the patient with a mutually protected or canine guidance occlusion and splinting implants together with no cantilever load. The 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.

Key words: Dental implants, Maxilla

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I. Introduction

A common treatment for edentulous patients is either removable complete or partial dentures. However, the use of removable dentures reduces the chewing capacity and taste perception[1]. Endosseous dental implants have become a predictable treatment option for applicable patients[2]. The success rate of dental implants is associated with bone quality and quantity[3]. Most implant failures occur in the maxillary molar region with poor bone quality[4,5]. Other factors that may cause failure and difficulty in implant placement in the posterior maxilla are limited visibility, reduced interarch space, and sinus pneumatization due to post-extraction bone resorption[6].

In cases with adequate vertical dimension of the residual alveolar ridge, conventional implants can be used with high survival rates and acceptable prognosis[7]. However, in atrophic maxillary bones, an implant with a rough surface can be used as compensation for poor bone quality and limited bone height[6]. This approach can be used with sinus augmentation using autogenous bone or sinus elevation as a solution for limited bone height to allow placement of conventional implants[6,8-10]. Long-term studies have shown that there is no significant difference between the success rates of implants placed in natural alveolar bone and those placed in grafted bone[11]. However, bone graft is not a possible technique for all treatments and is associated with increased postoperative morbidity, higher costs, and higher risks of complications during patient rehabilitation[8-11]. Some complications that can occur in patients undergoing sinus floor elevation are sinus membrane perforation, local infection, swelling, hematoma,

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maxillary sinusitis, and upper lip paresthesia[4].

Short implants were introduced recently as a new approach to simplify implant placement in compromised alveolar bone and to prevent possible damage to vital structures[11]. According to a study on 431 edentulous patients, the available bone height in the posterior maxilla in 38% of cases is at least 6 mm[12]. Moreover, implants that are placed in the posterior region are shorter than those in the anterior region[13].

Implants with 10 mm intrabone length have been defined as long implants, and those less than 10 mm were considered short implants. However, short implants have recently been defined as less than 8 mm in length[14]. There are many advantages to short implants including decreased contact possibility with adjacent tooth roots, lower risk of surgical paresthesia, less bone overheating, and lower risk of bone graft exposure. In addition, short implants lead to time and cost reduction and less patient discomfort[15]. Furthermore, short implants do not need computed tomography (CT) scans, since CT scans are usually invested for >10-mm-long implants or sinus augmentation surgery[6]. Moreover, studies have revealed that the failure rate of short implants was not higher than that of long implants[16,17].

There is still controversy on short implant indication because of challenges such as less bone to implant contact due to reduced implant surface, more crestal bone resorption due to a reduced surface over which to distribute forces, and the increased crown-to-implant (C/I) ratio[6].

II. Materials and Methods

An electronic search of PubMed and MEDLINE databases for relevant studies published in English from January 2004 to August 2015 was performed. Randomized clinical trials, human experimental clinical trials, and prospective studies (e.g., cohort as well as cases series) were selected to investigate the survival rate of short dental implants (<10 mm) for fixed prostheses or overdenture. Short implant, posterior maxilla, and survival rate were chosen as keywords. Twenty-four of 253 studies were selected after determining that they met the four following criteria: implant length <10 mm, placed in the posterior maxilla, data on survival rate, and at least one year of follow-up.

III. Literature Review

Monje et al.[18] performed a meta-analysis of 13 prospective clinical human trials published from 1997 to 2011, and examined 1,955 dental implants, 914 of which were short implants (<10 mm). They demonstrated that standard dental implants had a survival rate of 86.7% with a peak failure rate after 6 to 8 years of function, while short dental implants had a survival rate of 88.1% at 168 months with a peak failure rate after 4 to 6 years of function (P=0.254). The study revealed that standard dental implants failed later than short implants. However, in the long-term, short dental implants were as predictable as longer implants. Romeo et al.[19] demonstrated that some important factors affected short implants such as diameter and length of the implant, surface topography of the implant, C/I ratio, prosthesis type, occlusal/parafunctional loads, and splinting to other implants. Furthermore, additional influences were systemic factors and habits such as smoking and implant placement in host versus grafted bone. It is also notable that the length of bone-to-implant contact, which was measured after prosthetic connection, may be more related to implant survival than is the length of the implant placed into the bone[20].

1. Surface topography and diameter and length of the implant

Atieh et al.[20] carried out a systematic review of 1,354 studies, which led to direct evaluation of 401 articles. The selected studies evaluated short implants of less than 8.5 mm, which were placed in the posterior maxilla and/or mandible to support fixture restoration. They found no significant difference in the reported survival of short versus long implants. The initial survival rate of short implants for treatment of posterior partial edentulism was high and was not related to implant width, surface, or design. Anitua et al.[21], in a retrospective cohort study performed from 2001 to 2004, investigated 293 subjects who received 532 short implants with a diameter ranging from 3.3 to 5.5 mm and a length ranging from 7.0 to 8.5 mm. Subjects showed good periodontal health before implant placement, and antibiotics were prescribed for each patient from 30 minutes before implant placement to 6 days after surgery. Also, analgesic and anti-inflammatory drugs were administered 30 minutes before surgery. Twice daily chlorhexidine 0.12% rinses were recommended until the sutures were removed. Short implants were inserted by two surgeons, and the crowns were installed by prosthodontists. The potential influence of clinical factors, demographic factors, prosthetic variables, and surgery-dependent factors on implant survival was investigated. The overall survival rate of short implants after life-table analysis was 98.7% and

99.2% for subject- and implant-based analysis, respectively, at 31.0±12.3 months. Thus, under strict clinical protocols, short implant placement in the posterior maxilla can be considered predictable and safe.

In other retrospective study of 1,287 short implants, Anitua and Orive[22] found similar results over 8 years, with the same method. Kotsovilis et al.[23] performed a systematic review and meta-analysis to evaluate the effect of implant length on the survival rate of rough-surface dental implants and found no statistically significant difference between conventional (=10 mm) and short (<10 mm) rough-surface implants, placed in partially edentulous patients. Although some systematic reviews have reported comparable survival rates for conventional and short rough-surface implants, a comprehensive review by Hagi et al.[24] revealed that surface geometry (machined vs rough) played a primary role in performance of edentulous dental implants of length <7 mm. Also, Menchero-Cantalejo et al.[25] reported that the cumulative success rate of rough-surface short implants was higher than that of machined-surface implants.

Furthermore, Ketabi et al.[26] the implant stability and radiographic crestal bone loss in hydroxylapatite (HA) coated compared with restorable blast media (RBM) short dental implants placed in the posterior maxilla. The results revealed that the amount of crestal bone loss around HA-coated short implants was smaller than that of RBM, indicating that the HA-coated surface was more appropriate in areas with poor bone quality.

2. Placement of implant in host vs grafted bone

Peng et al.[27] suggested that elevation of the maxillary sinus floor with autogenous bone graft through the lateral window approach is safe and feasible. In addition, for patients with reduced vertical bone height in the posterior maxillary region, maxillary sinus floor elevation is typical in implant rehabilitation.

Nedir et al.[28] evaluated the efficacy of 37 short implants (8 mm), placed with accompanying osteotome sinus floor elevation (OSFE), in a residual bone height ≤4 mm over a period of 3 years. Healing time before prosthetic rehabilitation was 10 weeks. Results showed that atrophic posterior maxillae can be predictably rehabilitated using OSFE and simultaneous placement of short implants. Barone et al.[29] compared the survival rate of implants placed in augmented sinus with ones placed in host bone in the posterior maxilla. Their study contained 192 implants of 64 patients that were placed in pristine bone of the control group and 201 implants of 41 patients that were placed after preliminary sinus floor elevation in the posterior maxilla of the test group. The subjects in the test group were treated with the two-stage technique and were followed at 3, 6, and 12 months after implant placement and then every 6 months for the next 6 years. The findings revealed that implants placed in pristine bone had a higher survival rate (96.4%) compared with those placed in an augmented sinus (86.1%). All implant failures in the test group occurred before prosthetic rehabilitation.

Esposito et al.[30] performed a systemic review of horizontal and vertical bone augmentation techniques for dental implant treatment and reported a higher odds ratio (OR) of implant failure (OR=5.74) and more significant complications (OR=4.97) in patients who had received vertical augmentation. However, when comparing various horizontal augmentation techniques, no statistically significant differences were observed[8]. These authors, in another systemic review of augmentation surgery of the maxillary sinus, found that short implants (5 to 8 mm) can be effective and result in fewer complications than longer implants placed using more complex techniques. Corbella et al.[31] conducted a systematic review of 44 articles and evaluated the implant survival rate of different rehabilitation techniques (lateral approach to sinus floor elevation and osteotomy) in the posterior atrophic maxilla after a period of more than 3 years. Their review included (1) four articles including 901 short implants with up to 5 years of follow-up, (2) eight studies that evaluated 1,208 implants for the osteotomy technique after 3 years of follow-up, and 3) twenty-nine studies that assessed 6,940 implants placed in 2,707 sinuses augmented by the lateral technique. According to these three mentioned study sets, there was no significant difference in clinical outcomes of osteotomy or the lateral approach. Long-term evaluations of clinical outcomes demonstrated that sinus floor elevation with osteotomy and the lateral approach was the preferred therapeutic option for rehabilitation of the atrophic posterior maxilla. Short implants are a promising treatment option, but further long-term studies are required.

Thoma et al.[32] performed a systematic review comparing short implants (≤8 mm) in the posterior maxilla with longer implants (>8 mm), placed after or simultaneous to sinus grafting. The result indicated that shorter dental implants are an appropriate alternative approach with fewer biological complications and lower morbidity, costs, and surgical time. Shi et al.[33] investigated implant stability, surgical time, and patient satisfaction in three groups of short dental implants

(6 mm), short dental implants (8 mm) combined with OSFE, and standard dental implants (10 mm) combined with OSFE for treating atrophic posterior maxilla in partially edentulous patients. In total, 33 patients with 33 implants were involved in the study. In all three groups, high survival rates, adequate primary and secondary implant stability, and excellent patient satisfaction were achieved. The short 6-mm implant group demonstrated a significantly shorter surgical time than the other groups.

Schincaglia et al.[34] evaluated survival rate, marginal bone level alteration (MBL), periodontal probing depth, bleeding on probing, and C/I ratio of short (6 mm) and long implants (11-15 mm) placed with sinus floor elevation. Patients with 5 to 7 mm of bone height in the posterior maxilla were randomly assigned to receive short or long implants with sinus grafting. Implants were loaded with a single crown 6 months after placement. In 97 patients, 132 implants were re-assessed 12 months after loading, and there was no correlation between C/I and MBL, and the two treatment procedures provided similar outcomes.

3. Occlusal/parafunctional loads

Tawil et al.[35] investigated the influence of some prosthetic factors on the survival and complication rates and suggested that implants shorter than 10 mm can be a long-term solution for sites with reduced bone height. In this study 262 short machined-surface Brånemark System implants were consecutively placed in 109 patients and followed for a mean of 53 months. The opposing dentitions were implant-supported fixed restoration, natural teeth, and fixed prosthesis supported by natural teeth. The results indicated no correlation between peri-implant bone loss and C/I ratio or occlusal table (OT) width. Furthermore, increased C/I and OT values do not seem to be a major risk factor in cases of favorable loading. Cantilever length and bruxism had no significant effect on peri-implant bone loss.

4. Prosthesis type and crown-to-implant ratio

Misch et al.[13] evaluated 745 dental implants <10 mm long that supported 338 posterior restorations in 273 patients followed for up to 6 years. Implant survival rates were collected as follows: (1) stage I to stage II healing, (2) stage II to prosthesis delivery, and (3) prosthesis delivery to as end of follow-up. In the study, 240 implants healed with a one-stage surgical approach, while a two-stage surgical approach was performed on all other implants. The researchers decreased stress to the posterior implants based on the increased bone-implant contact surface area, providing the patient with protected or canine guidance occlusion and splinting implants with no cantilever load. The investigation results indicated that there were six surgical failures during the time from stage I to stage II healing (98.9% survival rate) and two failures from stage II healing to prosthesis delivery, but no implant failure occurred after the 338 final implant prostheses were installed. Therefore, this study shows that short-length implants can be used for supporting fixed restorations in posterior partial edentulism. Kim and Lee[5] reported that, in residual bone with a smaller than 4 mm vertical dimension, restoration of a single implant had a significantly lower survival rate compared with cases where the superstructure was joined to several implants in the area.

Mertens et al.[2] evaluated the long-term survival and success rate of 52 short 8 mm and 9 mm implants in 14 patients installed using the two-stage surgical approach and all prosthetic rehabilitations performed by the same prosthodontist. After 10.1 years, all patients were re-examined radiographically and clinically. According to the Karoussis et al.'s criteria[36], 4 implants failed; however, according to the Albrektsson et al.'s criteria[37], all implants were successful. Therefore, the results of this study show that the failure rate and marginal bone resorption in short and long implants are similar, and a higher C/I ratio did not seem to have any negative influence on implant success[2]. Birdi et al.[38] performed a retrospective cohort study of 309 implants placed in 194 patients who had 1 or more single-tooth, 5.7-mm- or 6-mm-long plateau-design implants placed and restored (cement retained, non-splinted) with use of the locking-taper design. The results of measurements of periapical radiographs (with a paralleling technique) and C/I ratios (with a software measurement tool) revealed that the success of those implants was not affected by the C/I ratio. However, some studies claimed that high C/I ratio has a negative biologic effect on crestal bone loss and suggested overloading as a result of higher bone stress leading to bone atrophy and greater marginal bone loss[39-41]. Anitua et al.[42], in a retrospective study, evaluated the influence of C/I ratio on marginal bone loss and on the survival rates of implant-supported prostheses in 128 short implants (≤8.5 mm in length) placed in the posterior maxilla or mandible of 63 patients over a period of 10 years. Based on the C/I ratio ($C/I < 2$ and $C/I \geq 2$), two groups were designed. According to this study, marginal bone loss in the posterior area is not significantly influenced by C/I ratio.

IV. Discussion

The use of the longest possible implants was defended based on the principle that longer implants would exhibit higher survival rates and more favorable prognosis[7]. However, in many clinical conditions, placement of long implants was doubtful due to limitations such as alveolar ridge deficiencies, maxillary sinus pneumatization, and inferior alveolar nerve canal position[43-47].

Because of different outcomes of treatment time, cost, and morbidity following advanced osseous augmentation techniques[7,38], short dental implants have been proposed as a treatment option to simplify implant placement in a compromised alveolar ridge, to avoid vital structures, to minimize surgical trauma, and to decrease the morbidity of advanced surgical procedures[48]. It has often been supposed that shorter implants will show a lower success rate than standard ones. Nevertheless, no distinctive linear relationship between survival rate and implant length has been scientifically established[49], and many studies showed that short dental implants have no more risk of failure than longer implants[20]. Because implant survival rates are affected by many factors such as implant surface, primary stability, bone quality and quantity, prosthodontics protocol, and overheating during surgical preparation[21].

Primary stability may be more difficult to achieve with short implants due to decreased bone-implant contact[11]. The contact area is determined by length, taper, diameter, and the surface texture[6]. Therefore, osseointegration of the bone-implant interface was increased by using wide-diameter or rough-surface implants[2,23]. Some studies indicated that the effect of diameter of the implant on survival rate is more important than the length[14]. Similarly, a meta-analysis showed that there is no statistically significant difference in survival rate between standard and short rough-surface implants in edentulous patients[23]. In addition, the greater was the bone-implant contact percentage, the less stress there was at the bone-implant interface[13].

Some risk factors that may increase stress when using short implants are (1) increased crown height, (2) high bone density in the region, and (3) higher bite force. Some methods available to decrease stress include (1) minimizing the lateral force on the prosthesis, (2) lack of cantilevers on the prostheses, and (3) splinting multiple implants together[13].

The C/I ratio of short implants might increase the risk of biomechanical complication because of overloading/non-axial loading and can eventually result in crestal bone loss[50]. Occlusal table reduction, flattening the cuspal incline, and minimizing off-axis loads would contribute to more favorable load distribution and potentially more success in implant treatment[6]. However, several studies reported that C/I ratio has no effect on the success rate of short implants and does not influence marginal bone loss[38,51].

Increasing the implant number and splinting short implants together or to long implants could increase the survival rate[41,52]. Bergkvist et al.[53] revealed that stress levels in bone surrounding splinted implants were significantly lower than stress levels surrounding uncoupled implants. Bone quality and site of implant placement seem to be main predictors of treatment outcome[54,55]. Some studies with short implants placed in the maxilla showed a lower survival rate than those placed in the mandible[49-56,57]. This result could be due to the difference in bone density, which can reduce stress concentration around implants and improve mechanical properties of the implant-bone interface, consequently facilitating primary stability and early osseointegration, which compensate the implant lengths reduction[57].

V. Conclusion

This study presents strong evidence supporting the use of short implants even in the posterior maxilla. The survival rate of short implants is a multifactorial parameter; however, the findings of this study indicate the predictability of short dental implants considering a precise treatment plan and strict clinical protocol.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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