

Literature Review Article

Predictability of short dental implants: a literature review

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Received for publication: April 15, 2010. Accepted for publication: June 9, 2010.

Keywords:

dental implants;
osseointegration; oral
rehabilitation.

Abstract

Introduction: In clinical situations where severe bone resorption has occurred following tooth loss, implant treatment options may comprise either a previous bone reconstruction or only the use of short implants. **Objective:** This non-systematic review summarizes and discusses some aspects of the use of short implants, such as: biomechanical aspects, success rate, longevity and surgical-prosthetic planning. **Literature review:** Current and relevant references were selected in order to compare short dental implants to conventional ones. Several studies have highlighted the great importance of wide-diameter implants. Dental short implants have shown high predictability and success rates when some biomechanical aspects are taken into consideration. **Conclusion:** Placement of short dental implants is a viable treatment method for patients with decreased bone height.

Introduction

Due to the development of dental implants and implant-supported prosthesis, formerly edentulous areas showing adequate bone height and width started to be successfully rehabilitated. This type of treatment's high success rate is increasingly providing confidence and clinical applicability to the dentist [11]. However, in areas displaying severe resorptions and bone height reduction, dental implant rehabilitation is limited, mainly in mandible and maxilla's posterior regions, where the mandibular canal and maxillary sinus floor, respectively, are present [18].

Surgical protocols employing bone grafting and reconstruction, as well as, inferior alveolar nerve transposition are an option for standard long implants rehabilitation treatments, in those areas. Although bone grafting evidenced a high success rate in Implantodontology, it has demonstrated varied and unpredictable outcomes. Moreover, many patients are unable or unwilling to undergo such surgical type due to several reasons, among them: high cost, need of multiple surgical procedures, poor general health [18]. Also, inferior alveolar nerve transposition procedure presents a greater risk of paresthesia [12].

With the advent of short implants, that is, lesser than 10 mm length [2, 5, 13, 14, 18, 20], dental implant rehabilitation at very much resorbed ridges is a less complex, costly, and traumatic treatment option for patients (figure 1). Whenever possible and well indicated, short implants use is a safe option for edentulous areas showing bone height and volume limitations [1, 11].



Figure 1 - Three different dimensions of external hexagon Colossom implants Evolution (Emfils® Indústria e Comércio de Produtos Odontológicos, São Paulo, Brazil). From left to right side: 5.0 x 6.0 mm; 4.0 x 10.0 mm; 4.0 x 16.0 mm

Therefore, this non-systematic literature review discusses the biomechanical aspects, success rate, longevity and surgical-prosthetic planning of short implant therapeutic option for resorbed bridge patients.

Literature review

In their study, ten Bruggenkate *et al.* [22] reported the following-up period from one to seven of 253 implants (45 on maxilla and 208 on mandible; 6.0 mm length and 3.5 or 4.1 mm width) with treated surfaces in 126 patients. In the study's following-up period, seven implants were removed, representing a survival rate of 97%. From these, five were removed in maxilla due to inflammatory process: four lost during healing phase, and one lost after two-year following-up. The other two implants lost (one on maxilla and one on mandible) occurred due to bone loss without clear signs of inflammation, although they were supporting single crowns on molar teeth. From the 246 implants left, only 210 were followed-up during six years, showing a success rate of 94%. The authors observed that bone quality seemed to be a decisive factor on the found outcomes, because six out of seven implants lost were placed on maxilla. They also believed that implant and surface treatment types performed an important role in the results, because they improved the implant's osseointegration capacity.

Tawil and Younan [21] followed-up 269 screw-type Branemark implants of 10 mm or short (6, 7, 8, and 8.5 mm), during 12 to 92 months (139 on mandible and 130 on maxilla), installed in 111 patients. General success rate was 95.5%. Twelve implants were lost. From those, five were 7.0 mm length, one was 8.0 mm length, two were 8.5 mm length, and four were 10 mm length. Two implants were lost due to early load; three implants were lost in a patient presenting osteoporosis; one in a patient showing severe bruxism; and one due to fracture. Two implants installed in dense bone are failed due to bone overheating during implant drilling. In three sites, implant loss could not be identified. There were no statistical differences ($p > 0.05$) in the success rate of 10 mm implants in comparison to short implants, as well as among the different diameters. According to the authors, bone quality is the most determinant factor for implant success compared to quantity.

Mordenfeld *et al.* [15] described the results of greater diameter implants of length between 7.0 and 13 mm employed for supporting fixed dentures on maxilla and mandible's posterior areas. From the 78 MK II wide-platform implants (Nobel Biocare™)

(29 short and 49 long implants) installed in 52 patients, aging from 19 to 81 years-old, followed-up during up to four years, eight implants were lost (six short and two long implants). This eight lost implants comprised five maxilla's implants and three mandible's implants. All losses occurred within a 2-year post-surgery period: three implants were lost prior to prosthesis installation; five implants were lost from eight to 20 months after load. General success rate was 89.8%; 79.3% for short implants and 95.9% for long implants. The authors considered the results encouraging since in wide-platform implants, unfavorable situations were found, such as: poor bone quality, compromised bone volume, and areas submitted to intense occlusal forces.

Griffin and Cheung [9] verified the success rates of wide-platform short implant with hydroxyapatite surface treatment installed at maxilla and mandible's molar area showing reduced bone height. Success rate was determined by the following criteria: lack of complaints, periimplantitis or suppuration, implant's mobility, and radiolucence in bone/implant junction. From the 168 implants (6.0 x 8 mm) placed in 167 patients, 128 supported single crowns, 38 were used together with other implants of varied size for supporting fixed partial dentures, and two were used in fixed cantilevered partial prosthesis. Following-up period comprised 68 months after implant loading. The authors found that the implants comprised the established success criteria.

Gentle *et al.* [6] investigated the success rate of Bicon™ short implants (6.0 x 5.7 mm) compared to long implants. Sample comprised 35 patients, in whom 172 implants were installed (45 short and 127 long). Concerning to short implants, 33 were placed into mandible's posterior region (73.3%), 11 into maxilla's posterior region (24.4%), and one into mandible's anterior region (2.3%). After 12 months, success rate reached 95.2% for short implants, and 95.2% for long implants, without statistically significant differences ($p = 0.78$). The results suggested that short implants may osseointegrated and supported occlusal loads.

Arlin [1] evaluated 630 implants ($n = 35$, 6.0 mm length; $n = 141$, 8.0 mm; $n = 454$, median between 10 and 16 mm). Implants with 6.0 mm length were placed into mandible's posterior area; implants with 8.0 mm and 10-16 mm length were installed into mandible and maxilla. The authors emphasized that more than half of the 6.0 mm length implants were placed into poor quality bone. Seventeen implants failed, which represented an absolute success rate of 97.3%. From these, 6.0 mm length implant success rate was 94.3% (two losses);

8.0 mm length implant success rate was 99.3% (one loss); and 10-16 mm length implant success rate was 96.9% (14 losses), during two-year following-up period. Moreover, 11 losses occurred in implants placed into type II or IV bone. The two 6.0 mm length implants lost during osseointegration phase had been placed into type IV bone. Concerning to implant losses, 76.5% occurred during the first year; 92% prior to prosthesis installation. It is noted that 6.0 to 8.0 mm length implants are a predictable treatment option for patients with limited bone availability. By comparing bone augmentation and longer implants to short implants' installation, the latter is simpler, less time-consuming, less costly, and offers low morbidity.

Romeo *et al.* [19] assessed the clinical effectivity of varied size implants (8-10 mm length; 3.75, 4.1, 4.8 mm width) installed into mandible and maxilla's different areas, in partially or completely edentulous subjects. During 14 years, 129 patients were treated with fixed dentures (single or multiple; screwed or cemented) supported by 265 implants (154 with 10 mm length; 11 with 8.0 mm length). The researchers used two types of treated surface implants: 141 of TPS type (titanium plasma sprayed) and 124 of SLA type (sand-blast, large-grit, acid-etched surface). Twenty-three patients failed to continue the research, therefore, 23 prosthesis supported by 42 implants could not be evaluated. Concerning to other patients ($n = 106$; 223 implants), eight implants failed (4 standard and 4 short), installed into type III and IV bone. Mean loss of marginal bone and probe depth of gingival sulcus associated to implant length were statistically significant ($p < 0.05$). Success rates during 14 years for all standard and short implants reached 97.9% and 97.1%, respectively. TSP short and standard implant success rates were 92.3% and 95.9%, respectively. SLA short and standard implant success rates were 100% and 98.5%, respectively. The authors affirmed that the employment of varied size implants seems not to compromise the implant effectivity in the population studied.

Misch *et al.* [13] analysed short implants installed into maxilla and mandible's posterior area. For this purpose, they used 745 implants in 273 patients. Most of these (562) present 4.0 x 9.0 mm; 89 present 5.0 x 9.0 mm, four present 6.0 x 9.0 mm; 60 present 3.5 x 9.0 mm; 29 present 4.0 x 7.0 mm; and only one present 5.0 x 7.0 mm. It was constructed 338 implant-supported fixed partial dentures, from which 102 were supported by one implant and 236 by multiple implants. In a 5-year following-up period, six losses were recorded (four in mandible and two in maxilla), which occurred

prior to implant load. Success rate reached 99.2%. Such fact shows that, by applying the biomechanical properties of stress reduction (adequate crown/implant ratio; number of implants similar to lost teeth; lack of cantilever; splinting; and reduction of the occlusal table), 7.0 and 9.0 mm length implant could present high success rates.

During a 2-14 year follow-up period, Melhado *et al.* [11] clinically evaluated Standard and MK-III cylinder and smooth-surface implants (Branemark system), with 7.0 mm length. The authors examined 198 fixtures in 99 subjects. Concerning to diameter, the Standard type implant ($n = 88$) has 3.75 mm and 4.0 mm ($n = 68$). MK-III implants presented a diameter of 4.0 mm ($n = 3$) and 5.0 mm ($n = 28$). These implants supported 73 fixed partial dentures in the mandible's posterior area, 20 complete dentures, and 6 single crowns. In relation to fixed partial dentures, 15 were supported only by 7.0 mm length implants. The others ($n = 58$) used a combination of 7.0 mm length with implants of varied sizes. Four out of 20 complete dentures were supported by 3.75 x 7.0 mm implants. Sixteen presented implants with varied diameters and lengths. Also, eight dentures received early load. Seven out of 198 implants were lost (96.46% of success rate): five Standard-type, and two MK-III type. In mandible, short implant success could be compared to long implants of the same system. Accordingly, they have been recommended as a reliable and predictable alternative for rehabilitation of mandibles with high degree of bone resorption.

Barboza *et al.* [2] assessed the clinical performance of short implants (220, 9.0 mm length; 128, 10 mm length; diameter of 3.5, 4.0, or 5.0 mm), during 6 years. It was installed 348 implants into 153 subjects. In 19 cases, early installation of implants was performed. All implants were prosthetically rehabilitated with single or multiple prosthesis. Success rate reached 96% (334 implants). Five losses occurred due to early spontaneous exposure; four due to periimplantitis; three due to early load; and two due to lack of osseointegration. The results obtained by the authors proved that short implants can be used, safely, for supporting prosthesis in the rehabilitation of lost teeth, displaying success and longevity rates similar to long implants.

Maló *et al.* [10] reported the installation of short implants aiming to test the hypothesis whether short implants placed into atrophic mandibles would provide results similar to the success rates of longer implants installed into higher bone volume. This retrospective clinical study comprised 237 patients

rehabilitated with 408 short Branemark implants, which supported 151 fixed dentures. One hundred and thirty-one implants had 7.0 mm and 277 had 8.5 mm length. Prosthetic abutments were installed at the surgery, and the prostheses were installed four to six months post-surgery. 126 out of 131 7.0 mm length implants (96%) were followed-up for one year, 110 (84%) for two years, and 88 (67%) for five years. In four subjects, five implants failed prior to 6 months, contributing for the success rate of 96.2%, at the five-year following-up period. The mean bone resorption was 1.0 mm after the first year, and 1.8 mm after five years of load. 269 out of 277 8.5 mm length implants (97%) were followed-up for one year, 220 (79%) for two years, and 142 (51%) for five years. Eight implants were removed prior to six months, in seven patients, which reached a success rate of 97.1%, at a five-year period. Mean bone resorption was 1.3 mm after the first year and 2.2 mm after five years of load. The results indicated that one-stage short Branemark implants, both in mandible and maxilla, were a viable treatment option.

Grant *et al.* [8] investigated the success rate of 335 short implants (8.0 mm) placed into mandible's posterior region, in partial (112) or total (12) edentulous areas. Subject's ages ranging from 18 to 80 years-old, mean of 56 years-old. From these, 32 received single implant, while 92 received multiple implants. Early load was performed in one implant. The implants supported fixed dentures, from which 245 were splinted and 75 were individually restored. Four failures occurred: two in cases of porous hydroxyapatite grafts, one in platelet-rich plasma graft, and one at the head of implant already in function for 10 months. Success rate percentage of 8.0 mm implants, in mandible, reached 99%, during two years. The authors concluded that short implant placement is an acceptable treatment for reduced bone height at mandible's posterior area.

Corrent *et al.* [3] realized a prospective research for determining the success rate, during 36 months, of short porous implants at maxilla's posterior area, with initial bone height of 2.0 to 7.0 mm, in 48 patients. Forty-eight implants were installed and loaded by single crowns. Thirty-five implants were placed into sites with bone height of 5.0 mm or less. Thirteen patients needed maxillary sinus augmentation procedures, which were performed by osteotomy and xenografts. At the end of the follow-up period, success rate reached 97.92%. Short porous implants usage showed good treatment predictability at posterior maxilla.

Discussion

We noted that there is not a consensus among authors on implant length for considering an implant short. Most of the authors [2, 5, 13, 14, 18, 20] considered as short, implants with length smaller than 10 mm. Some researches [6, 22] stated that short implants are those with length equal or smaller than 10 mm. Another author [17] believes that short implants should have length smaller than 8.0 mm. In this study, we considered a short implant with length smaller than 10 mm, corroborating most of the literature searched.

In 2003, Pierrisnard *et al.* [16], through finite element method, proved that the implant length could not be positively affected by the stress transmitted through it and affirmed that the diameter increase reduces the tensions' intensity along the implant length (figure 2). On the other hand, according to Morand and Irinalis [14], the implant's diameter and extension should be taken into account, concomitantly, due to their interactive effects; the diameter is the most influent factor. By corroborating this affirmation, Misch *et al.* [13] stated that the area of most effort transmitted to implant is the bone crest while the apical area receives less stress. Therefore, implant length may not be the most important factor in the distribution of loads at bone/implant interface.

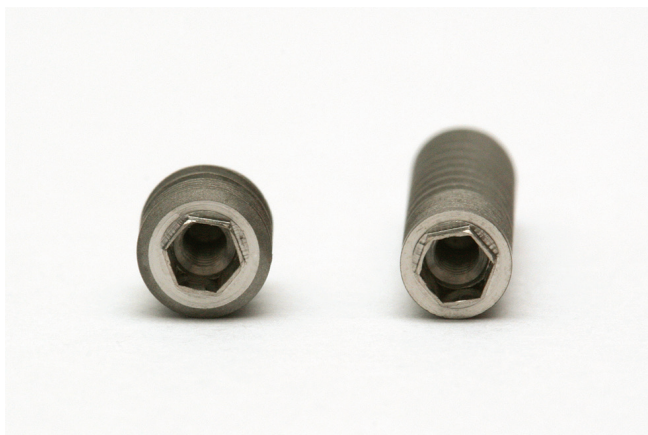


Figure 2 - Two different diameters of external hexagon Colossom implants Evolution (Emfils®). From left to right side: 5.0 mm (wide platform); 4.0 mm (regular platform)

Some studies [1, 2] compared the success rates of short to long implants. Short and long mean success rate reached 91.4% and 97%, respectively. According to Winkler and Nisand [23], short implants are more likely to fail than long implants, both at the re-opening surgery and load stage, due to occlusal load excess. Despite of that, other authors

[2] found that most short implants losses occurred prior to masticatory force submission. Romeo *et al.* [19] observed that short implants present favorable outcomes in comparison to long ones and concluded that short implants can be successful in residual bone with reduced height, mainly if they were splinted to other implants. Renouard and Nisand [17] emphasized the necessity of splinting and stated that prostheses supported by one or two implants replacing posterior teeth are submitted to high risk of occlusal overloads.

High intensity occlusal loads occur due to moments of high flexion, of unfavorable distribution, and of strong force magnitude [14]. The increasing of the stress at posterior areas explains why long implant success rates, at such areas, are higher than short implants. According to Misch *et al.* [13], in these areas, the prosthetic crown height, great occlusal loads, and bone density, contributes to the indexes found. The crown height is considered as a vertical cantilever, increasing the load over implants. Biomechanical measurements as crown height reduction, splinting, lack of cantilever, and lack of lateral forces reduces the losses percentage.

Clinical studies [4, 22] evidenced that high success rates (97.7%) were achieved when 6.0 mm height implants were installed and splinted with long implants. Arlin [1] splinted adjacent implants without taking into consideration their lengths. However, since this study's sample was small, the author did not draw any conclusion regarding the effect of implant extension on splinting.

Maló *et al.* [10] found a short implant success rate of 99% in mandible and 92% in maxilla. According to these authors, the maxilla's spongy bone, probably, influenced on the losses, and consequently on the success rate. On one hand, other study [15] also reported higher success rates of mandible compared to maxilla: 94.5% and 78.3%, respectively. On the other hand, in the study of Arlin [1] 630 implants were installed and 17 were lost. From these, 16 were placed into mandible, and only one into maxilla, with 11 located into type III or IV bone.

For several researches [6, 9, 14], bone quality is a significant risk factor for failures due to lack of blood irrigation, overheating during implant drilling in dense bones, and lack of bone density in trabeculated bone. Goodacre *et al.* [7] considered that implants performed in poor bone quality areas showed unsuccessful rates of 16% higher than those placed into grater bone density areas. One way of compensating the lack of bone quality would be to employ different techniques of implants' surface treatment and machining.

In the study of Griffin and Cheung [9], 168 implants (6.0 mm x 8.0 mm) with hydroxyapatite treated surface were installed into 167 patients. Success rate reached 100% in a following-up period of 68 months. Romeo *et al.* [19] installed 265 implants (141 TSP and 124 SLA), with a success rate percentage of 94.1% for TPS implants and 99.2% for SLA implants. By corroborating the aforementioned findings, Misch *et al.* [13] assured that the treated surfaces presented a large area in contact with bone. Consequently, they lead to less stress at bone/implant junction, displaying higher success rates.

Most of the authors [3, 5, 8-10, 15, 22] advocates the two-step surgery for short implants' installation. The time elapsed between the surgical and load stage should be four to six months for maxilla and two to four months to mandible.

Conclusion

Based on the literature review, it can be concluded:

- implant diameter seemed to be more efficient than length for dissipation of tensions, because the area receiving large effort is the bone crest;
- although displaying a higher loss index, short implants present success rates close to standard long implants;
- the following measurements: splinting, similar crown/implant ratio, reduction of the occlusal table, and lack of cantilevers, have favored the biomechanics and increased treatment predictability;
- bone quality and implants' surface treatment have been primary factors for short implants success. Areas with type III and IV bone showed more failures, regardless of the surface treatment;
- a two-step surgical protocol is safer for short implants' treatment.

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How to cite this article:

Galvão FFSA, Almeida-Júnior AA, Faria-Júnior NB, Caldas SGFR, Reis JMSN, Margonar R. Predictability of short dental implants: a literature review. *RSBO.* 2011 Jan-Mar;8(1):74-80.
