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Critical review of literature on the use of short implants

E. CIARMATORI[1], A. PASSARETTI[2], G. MIRACOLO[3], A. CICCONETTI[1]

[1] DDM, Dental surgery student, Dept. of Oral and Maxillofacial Sciences, School of Dentistry, Sapienza University of Rome, Italy
[2] DDM, Phd student, Dept. of Oral and Maxillofacial Sciences, School of Dentistry, Sapienza University of Rome, Italy
[3] DDM, Attending Doctor, Dept. of Oral and Maxillofacial Sciences, School of Dentistry, Sapienza University of Rome, Italy
[4] MD, DDS, Professor, Dept. of Oral and Maxillofacial Sciences, School of Dentistry, Sapienza University of Rome, Italy

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ABSTRACT

Aim The aims of this review were to verify the validity of short implants as a treatment option in patients with partial or total edentulism, having more or less atrophic jawbones.

Methods A systematic review of randomized controlled trials (RCT) was conducted, involving also prospective and retrospective studies published in English language between January 2005 and December 2015. The PubMed and Scopus databases were electronically analyzed. Titles and abstracts were selected, and full texts were evaluated. The data were organized in tables and then presented as a narrative analysis.

Results The electronic search provided 891 publications, 50 articles were retrieved in full text and only 11 were included in the review. Although the performance of the implants was evaluated through different success and survival criteria, short implants have shown to have a similar performance to longer implants.

Conclusions Short implants could be considered as a treatment option comparable to traditional lenght implant. However, other studies must be conducted to assess uniform criteria to state the quality of treatment.

KEYWORDS Short implant, Implant success, Implant survival.

INTRODUCTION

Missing teeth are commonly replaced by fixed or removable dental prosthesis, in order to restore stomatognathic functions and aesthetics (1-3). An implant-supported prosthesis is the first choice to restore the occlusal plane because it allows forces transmitted to the bone comparable to those of the teeth (4). Implants inserted into jawbones can support a prosthesis through osseointegration, the functional and structural connection between bones and implant surface (1-3). Frequently, there is a reduced alveolar bone height for implant placement, due to atrophy, trauma, or surgical resection (1), that not only limits the implant placement but also increases the chances of damaging the inferior alveolar nerve, maxillary sinus and the nasal cavity (5). It is often necessary to restore an adequate bone volume through suitable procedures like GBR, vascularized and non-vascularized bone graft, and tissue engineering (1, 6, 7). Vertical ridge augmentation requires an adequate healing time, increased costs, it depends on a surgeon's experience and is not free from complications (8). In the end, bone augmentation procedures can fail and implants placed in these areas do not necessarily reach the long-term survival rates of dental implants placed in pristine sites (9). Thus, the use of short implants has been suggested as a treatment option more accessible for both patients and clinicians (10).

Agreement is lacking about the definition of "short implant" in the literature. Some authors define as "short implant" an implant with an intraosseous length of 8 mm or less (11), others as an implant with a length equal to or less than 10 mm, or with a length of less than 7 mm. Other authors define a "short implant" as an implant with a length less than 11 mm (5).

In the past, short implants were associated with lower survival rates and with unpredictable long-term results (12). However, recent clinical studies indicate that short implants may adequately support most prosthetic restorations (13). This is due to improved surgical techniques and advances in implant characteristics, such as implant design, surface structure to optimize the biological responses of initial peri-implant bone healing (14, 15), implant macrogeometry that should encourage the formation of a greater peri-implant bone volume to dissipate the masticatory loads and reduce the stress due to reduced implant length (16-19).

Given the difficulties and disadvantages associated with bone augmentation procedures for the insertion of standard endosseous implants, short implants have emerged as a more accessible option for both patients and clinicians. Thus, the main purpose of this review was to verify the validity of short implants as a treatment option in patients with partial or total edentulism, having more or less atrophic jawbones. Another aim was to highlight any critical issues related to the use of short implants.

MATERIALS AND METHODS

The Medline database of the National Library of Medicine and the Scopus database were searched for articles published between the years 2005 and 2015 that included in their results the survival and/or success rates of short implants, for both short and standard implants, the marginal bone loss, and the number of failed implants. The searches were undertaken with the following search strings: ("short implant" OR "short implants") AND ("success*" OR "survival*"), ("short implant" OR "short implants") AND ("long* implant*" OR "standard implant*"), ("short implant" OR "short implants") AND ("augmented bone" OR "bone augmentation"), ("short implant" OR "short implants") AND atroph*, ("short implant" OR "short implants") AND alveolar bone loss.
Only studies published in English were taken into account. Randomized controlled trials, observational prospective and retrospective studies performed on at least 50 human subjects (both males and females aged >18 years) were included in the review. Only studies with subjects who needed the insertion of implants, who were partially or totally edentulous and having more or less atrophic or regenerated jawbones, were included. Studies conducted on subjects with contraindications for implant therapy were not included, in order not to affect the success and survival rates. Only studies that involved the insertion of short implants, or both short and standard implants with specified number and length were included. Studies in which the prosthesis provided splinting of short implants with longer ones or with natural teeth were excluded. No restrictions were placed on the type of implant used, the surgical protocol applied, and the type of prosthesis used. The minimum follow-up to consider the study was established as 12 months after the functional loading of implants. The data resulting from the studies selected were organized in tables and then presented as a narrative analysis.

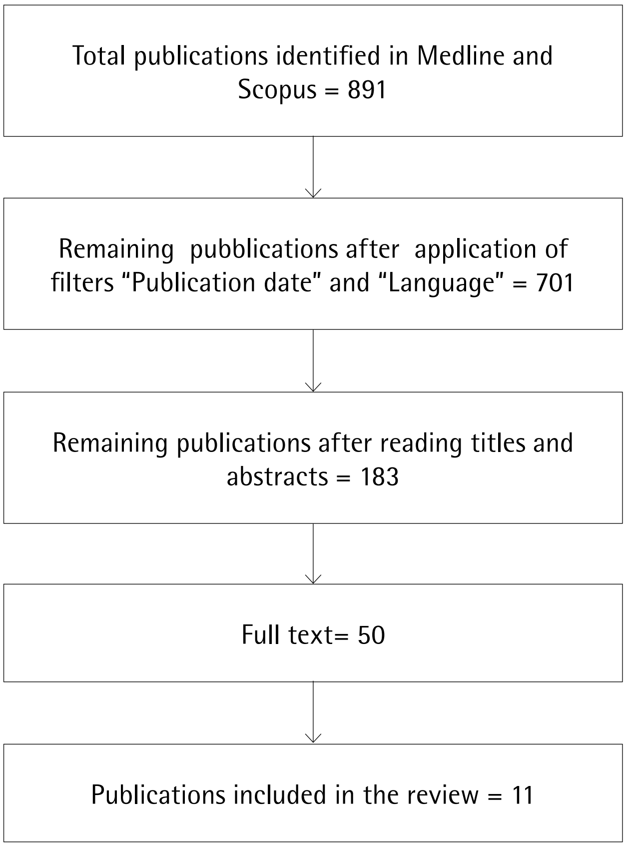

FIG. 1 Process selection of studies to be included in the review.

Cause of exclusion	Number
Pubblication date	171
Language	19
Selection criteria (insufficient number of subjects, review, short follow up, other reasons)	518
Repetition within each database	90
Medline	55
Scopus	35
Repetition within the two databases	43
Selection criteria after full text reading	39

TABLE 1 Number of publications excluded from the review and the causes of exclusion.

RESULTS

The Medline and Scopus analysis identified 891 publications. Figure 1 shows the process of study selection to be included in the review. Limiting the search to articles published between January 2005 and December 2015, written in English, applying filters "date of publication" and "language" returned 701; of these, the titles and abstracts were read and 183 studies were identified as meeting the selection criteria.
After eliminating double publications in each database (55 in Medline database, 35 in Scopus database) and between the two databases (43), 50 articles were retrieved in full text, and only 11 of them met all the inclusion criteria. Table 1 shows the publications excluded during the study selection and the causes. Table 2 lists the 11 publications included in the review.
Among them, four were randomized controlled trials,

four retrospective studies and three prospective studies. Two studies were multicentric, two were performed in private practices, five within a university, one in a private center and the information was not available in one case. Seven studies had considered only short implants (Table 3), and four studies compared short to longer implants (Table 4).
In the selected studies, short implants with different lengths were used, ranging from a minimum of 6 to a maximum of 11 mm. Implants with different geometry and surfaces were inserted in the cases. Various surgical protocols and functional loading protocols were used for patient rehabilitation, and different types of prosthesis were applied. The performance of the implants was evaluated through different success and survival criteria, and the follow up period was very different among the studies, ranging from one to twenty years. Various statistical methods were used. All studies reported the survival rates of short implants, although only three of them also clearly reported the success rate (Table 5). In three studies (20-22), the criteria used to define a successful treatment were explained, but then the results were reported as survival rates.
In a retrospective study (Table 3), Mendoça et al. (23) specifically evaluated the survival rate and the marginal bone loss around splinted and non-splinted short implants (≤10 mm). Although the authors found a lower success rate for non-splinted short implants and a higher failure rate for short implants ≤ 10 mm, they did not find a significant difference in the success and the marginal bone loss between splinted and non-splinted implants.
In three other studies both splinted and non-splinted implants (20, 22, 24) were used, but the specific differences between the two types have not been evaluated. Only two studies exclusively used splinted

Authors and year of pubblication	Type of study	N patients	Age range patients'	Mean age patients'	Place of study	Follow up
Degidi et al. 2007	Retrospective	134	41-80	56	-	Mean 45 months
Strietzel e Reichart, 2007	Prospective	131	18-81	57.0	University	55 months Mean 33
Malò et al., 2011	Prospective	127	23-78	53±9.7	Private center	12 months
Lops et al., 2012	Retrospective	121	22-69	54	University	20 years
Telleman et al., 2012	RCT	80	18-70 platform-switched 27-67 platform-matched	48.0±13.8 platform-switched 51.6±10.60 platform-matched	University	12 months
Gulié et al., 2013	RCT	95	26-70	54	Multicentric	12 months
Lai et al., 2013	Retrospective	168	23-72	45.9	University	10 yearsMean 7.22
Telleman et al., 2013	RCT	92	18-70 platform-matched 21-67 platform-switched	50.2±13.0 platform-matched 51.0±10.4 platform-switched	University	12 months
Mangano et al., 2014	Prospective	194	24-74	49.1±11.5	Private practice	10 years
Mendonça et al., 2014	Retrospective	198	45-81	*M 62.1±11.0 F 58.8±12.6	Private practice	3-16 years Mean 9.7±3.7
Schincaglia et al., 2015	RCT	101	20-75	50.5	Multicentric	12 months
*M=male; F=female						

TABLE 2 The works included in the review.

Authors, year of pubblication, implant characteristics*	N implants	Implant length mm	Succes rate %	Survival rate %	Marginal bone loss mm	N lost implants	Drop-out **	Follow up
Degidi et al. 2007	133	6,5-10	-***	97,7		3	-	
Implants<10 mm					-0,2****			38,1 months
Implants=10 mm					-0,5****			53,1 months
Malò et al. 2011	217	7	-	95,4	1,27 ± SD 0,67	10	3	1 year
Telleman et al. 2012	113	8,5	-				-	1 year
Implants platform-matched	58			93,1	0,73±0,48	4		
Implants platform-switched	55			94,5	0,51±0,51	3		
Lai et al. 2013	231	Intrabony length ≤8,5	-	98,3	0,63±0,68	4	-	10 years
Telleman et al. 2013	149	8,5	-				1	1 year
Implants platform-matched	76			92,1	0,74±0,61	6		
Implants platform-switched	73			95,9	0,50±0,53	3		
Mangano et al. 2014	215	8,5	95,9	98,5	0,62±0,31	3	5	10 years
Mendoça et al. 2014	453	≤10					-	9,7±3,7 years
Splinted implants	219		97,7	97,8 implants = 10 mm 98,8 implants = 8,5 mm 95,9 implants = 7 mm	1,22±0,95	5		
Non - splinted implants	234		93,2	96,7 implants= 10 mm 86,1 implants = 8,5 mm 88,9 implants= 7 mm	1,27±1,15	16		

* The table shows the breakdown of the results as presented in the studies, according to various implant characteristics.
** Drop-out regarded as the number of patients who have failed the recall appointments established in the study.
*** The result was not reported in the study.
****ΔIAJ="Delta insertion abutment junction": is an indicator of marginal bone loss. The IAJ (insertion abutment junction) is the difference between the implant abutment junction and the marginal bone level and the ΔIAJ is the difference between IAJ at the last control and IAJ recorded just after the operation.

TABLE 3 The seven studies that had considered only short implants.

Authors and year of pubblication, type of implant*	N implants	Implant length mm	Success rate %	Survival rate %	Marginal bone loss mm	N lost implants	Drop-out	Follow up
Strietzel et al. 2007	333		-**			5	4 patients	Mean 33 months
Long implants		13-16		97,6	0,9 mesial 0,9 distal	4	3	
Short implants		9-11		99,4	1,2 mesial 1 distal	1	5	
Lops et al. 2012	257						30 patients 50 implants	20 years
Long implants	149	10	81,4	95,9	1,9	4		
Short implants	108	8	78,3	92,3	1,8	4		
Gulié et al. 2013	208		-				2 patients	12 months
Long implants	101	11		99	0,02	1		
Short implants	107	6		97	0,06	3		
Schincaglia et al. 2015	137		-				3 patients	12 months
Long implants	70	11-15		98,6	-0,37±0,59	1	1	
Short implants	67	6		97,0	-0,22±0,3	2	3	

* The table shows the breakdown of the results as presented in the studies, according to implant type (long or short).
** The result was not reported in the study.

TABLE 4 The four studies that compared short with longer implants.

Authors and year of pubblication	Success rate %	Follow up
Lops et al., 2012	78.3	20 years
Mangano et al., 2014	95.9	10 years
Mendoça et al., 2014	97.7 splinted implants 93.2 non - splinted implants	Mean 9.7±3.7 years

TABLE 5 The three studies that clearly reported the success rate.

implants (21, 25).
In five studies short implants supported exclusively single crowns, and therefore the implants were not splinted (12, 26-29). In one of these studies, the long-term result of short (8 mm) locking-taper implants (12) was specifically evaluated, and the authors concluded that the restoration of single edentulous gaps in posterior regions was reliable with this type of implants. In two studies Telleman et al. (26, 27) specifically evaluated the result of short implants with a platform-switched connection compared to short implants with a platform-matched connection. Survival rates and the marginal bone loss are shown in Table 3. One year after the functional load, in both studies the marginal bone loss around short platform-switched implants was significantly smaller than around short platform-matched implants. In the study of Schincaglia et al. (29) only platform-switched implants were used, reporting a survival rate of 97% and a marginal bone loss of -0.22 ± 0.3 mm.
In ten studies short implants were inserted in both maxilla and mandible (12, 20-28) and two of these reported a higher failure rate for implants placed in the maxilla. This trend has been attributed to the greater likelihood of finding type III or IV bone in maxillary posterior regions (24) or to increased surgical challenges in these

areas (25). Short implants were inserted exclusively in the upper jaw in only one study (29). In one study, there was a significant number of failures in short implants inserted into type IV compared to type III bone (28). No differences were found between bone quality regarding the survival rate or failure rate of short implants in other studies (12, 20, 21).
In eight studies implants were inserted exclusively in posterior regions (12, 22, 23, 25-29) and in the remaining three studies implants were placed in both posterior and anterior sites (20, 21, 24). No significant differences were found in failure rate (20) or survival rate (21, 24).
Degidi et al. rated the behavior of immediately loaded short (≤10 mm) implants resulting in a survival rate of 97.7%. The authors concluded that the immediately loaded implants have a high success rate and survival rate after a median follow-up of 45 months. From the point of view of marginal bone loss, short implants with greater length (= 10 mm) have shown best results (21).
Survival rates and the marginal bone loss in studies comparing short to longer implants are shown in Table 4. No significant differences were found between the survival rates of short and longer implants in the four studies. Lops et al. (24) also reported success rates corresponding to 81.4% for standard implants and to 78.3% for short implants, with no significant differences between them. The results of the study confirm that short implants have a high reliability (24) and short implants of 6 mm were as reliable as those of 11 mm (25). The study of Strietzel et al. (20) confirms that the prognosis for short implants is comparable to that of long implants, and a study by Schincaglia et al. (29) indicated that 6 mm short implants have clinical and radiographic performances similar to those of longer implants when placed in combination with sinus lift.

DISCUSSION

The papers included in this review are heterogeneous in terms of methods, terminology and objectives. Univocal considerations cannot be drawn. However, some general considerations can be drawn.
When comparing splinted and non-splinted short implants, Mendoça et al. did not find any significant differences between the implant success and the marginal bone loss around the splinted and non-splinted implants (23). A finite element analysis showed that restorations with splinted implants led to a better distribution of stress on the implant body and bone as compared to restorations without splinting implants, especially when the load was applied to the center of the implant body (30). In contrast, other clinical studies have shown a greater marginal bone loss around the splinted implants (31). These controversial results have created doubt among clinicians and patients about the need for splinting implants. The Frost's law should probably be recalled. The bone reacts to the functional load by improving its architecture (32). Therefore the function stimulates the bone to absorb and distribute stress (18, 19). Splinting is not necessary when the occlusal load is adequately transferred to the bone.
In studies where short implants support single crowns, these have been shown to be a reliable mode of treatment (12, 28). Mangano et al. used locking-taper implants: they consist of a fixture and an abutment joined together by a self-locking connection thanks to a Morse taper driven by an internal hexagon (12). It has been shown that this type of connection can reduce the inflammation of peri-implant soft tissues, providing an efficient bacterial seal, and can ensure the long-term stability of the crestal bone (33, 34).
Telleman (26, 27) analyzed platform-switched and platform-matched short implants and showed significantly less marginal bone loss around the platform-switched short implants than around the platform-matched ones. This difference can be attributed to the concept of platform switching. It has been shown that this connection favors the maintenance of crestal bone, contrary to what happens using platform-matched implants. The platform-switching concentrates the stress in the central area of the body implant, reducing the stresses on crestal bone, and moves the implant-abutment junction horizontally towards the central portion of the implant, far from the bone crestal joining implant-abutment and, therefore, the inflammatory infiltrate responsible for bone resorption (26, 35). The results obtained in these two studies are consistent with a recent meta-analysis that found a significantly lower loss of marginal bone around the platform-switched implants than platform-matched (36). Thus, the results of the two studies confirm the data in the literature. A study by Schincaglia et al., in which only platform-switched implants were used, would seem to confirm these results (29).
In two studies, a higher implant failure rate was found for short implants placed in maxilla. In one study, this trend was explained by the higher probability of finding a bone type III or IV in the posterior regions of the upper jaw (24). Moreover, Lai et al. recorded a significant number of failures in short implants inserted into bone type IV compared to those inserted in bone type III (28). In 1985, Lekholm and Zarb subdivided the quality of bone tissue into four classes, based on the relationship between cortical bone and trabecular bone in the site considered (37). In the literature, poor bone density and quality in edentulous sites are reported as risk factors for short implants, in combination with smooth implant surfaces (38). As mentioned before, an adequate transmission of forces to the bone could improve performance. The bone can remodel in response to functional load (32).
When comparing short implants basing on the positioning site, no significant differences were found

(20, 21, 24). This support the theory that maybe doesn't matter the position but the bone quality.
In a study in which the authors assessed the performance of immediately loaded short implants (21), although they concluded that this type of rehabilitation showed high success and survival rates after a median follow-up of 45 months, greater marginal bone loss was observed around short implants ≤10 mm. Traditionally, implants are inserted in healed sites and the functional load is applied after a submerged healing of 3/6 months (39). An immediate loaded implant is defined as an implant that is loaded within the same week as its insertion (40). The crucial point for success with immediate loading is the control of the micro-movements during the healing phase. The peri-implant bone healing is a thorough process. The scaffold given from the fibrin clot lead to neo-angiogenesis and to osteoconduction (41). An inadequate or excessive load could influence this process.
Only four studies included in this paper clearly analyzed the difference in performance between short and long implants. All of them shown similar performances between long and short implants. No significant differences were found at the latest follow up of a 8 millimeter implant after 20 years (24).

CONCLUSIONS

The literature on the subject is prolific. This testifies to the interest in the subject. However, non-univocal methodologies are adopted in the papers. Often undefined terminologies are used. The purpose of this work was to verify the validity of short implant therapy. For the reasons mentioned above, the included studies are partially comparable. However some final considerations can be drawn.

- The concepts of locking taper and platform switching have proven useful in preserving peri-implant bone tissue.
- The success of a short implant is not influenced by the insertion position rather than the quality of the recipient bone.
- The implant's ability to transmit bone forces is crucial in achieving stable and functional osseointegration.

In conclusion new and detailed studies are recommended in order to state with the reliability of short implants. In particular, univocal terms are recommended and a main attention on the quality aspect of treatment is required.

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