

New approach towards mini dental implants and small-diameter implants: an option for long-term prostheses

Alvydas Gleiznys, Gediminas Skirbutis, Ali Harb, Ingrida Barzdziukaite, Ieva Grinyte

SUMMARY

Background. Mini dental implants (MDI) and small diameter implants (SDI) have been extensively used as temporary or orthodontic anchorage; however there have been studies that proved their availability as a mean for long term prosthodontics. Our aim was to review the indications, advantages of MDI and SDI, and their long-term survival.

Methods. Computerized searches were conducted for clinical studies between year 2000 and 2011 that involved either implants with 3.3 mm diameter or less, used in prosthodontics; or provided a follow up of MDI or SDI duration of at least 4 months following implant placement including survival rate data. All studies about implants used in orthodontics were excluded. The range of available MDI and SDI has been found in catalogues of the companies: 3M ESPE IMTEC, Bicon Dental, Zimmer, Implant Direct, Intra lock, Hiossen, Simpler Implant, KAT Implants, OCO Biomedical, American Dental Implant.

Results. 41 studies meeting the above criteria were selected, 22 out of them reviewed survival rates of MDI and SDI. The follow up duration varied from 4 months to 8 years with survival rates between 91.17 and 100%. Nevertheless, the companies showed a big variety of MDI and SDI provided in the market for long term prostheses.

Conclusions. Implants with small diameters can be used successfully in a variety of clinical situations. Less surgical time, less postoperative pain, ability of direct loading after surgery with no harm to bone and cost effectiveness are the advantages. The reduced surface implants require correct treatment planning so that the loading force would not cause bone loss or implant failure. MDI and SDI show high survival rates, but special cautions for bone quality and good oral hygiene should be maintained.

Key words: mini dental implants, small diameter implants, survival.

INTRODUCTION

It has always been a challenge to come up with the best way to replace missing teeth since ancient times. Previously, dentures were the standard way

for replacing missed teeth. However, nowadays, science, technology and number of researches have made it possible to improve our choice for better care of teeth and understanding the oral health leading to perfect deal with most of the oral problems. Osseointegration has become the main concept in modern implantology, this lead to introduction and refinement of the osseointegrated root form implant. Nowadays, available implants vary in diameter between 1.8 mm and 7 mm: implants with diameter less than or equal to 2.7 mm are called mini diameter implants (MDI) (1-5), while those of 3 to 3.3 mm (6, 7) diameter are called small diameter implants (SDI), and conventional implants are those up to 7 mm (1, 8). In the beginning, mini dental implants were used for stabilization of provisional construction for the time necessary for osseointe-

¹Department of Dental and Maxillary Orthopedics, Faculty of Odontology, Medical Academy, Lithuanian University of Health Science, Kaunas, Lithuania

²Faculty of Odontology, Lithuanian University of Health Science, Kaunas, Lithuania

³Kupiskis Primary personal healthcare center, Kupiskis, Lithuania

Alvydas Gleiznys¹ – D.D.S., PhD, assoc. prof.

Gediminas Skirbutis¹ – D.D.S., assist.

Ali Harb² – student

Ingrida Barzdziukaite¹ – D.D.S., assist

Ieva Grinyte³ – D.D.S.

Address correspondence to Dr. Alvydas Gleiznys, Department of Dental and Maxillary Orthopedics, Faculty of Odontology, Medical Academy, Lithuanian University of Health Sciences, Sukilėlių pr. 51, LT-50106 Kaunas, Lithuania.

E-mail address: algleiznys@gmail.com

Table 1. Commercially available SDI and MDI implants

Implant company	Implant name	Diameters	Lengths	Prosthesis used	Type of fixed abutments	Surface treatment
3M™ ESPE, IMTEC	Classic MDI™ Implants Standard Thread Design	1.8 mm, 2.1 mm	10, 13, 15, 18 mm	Removable dentures and overdenture	O-Ball prosthetic Head – for denture stabilization, Square Prosthetic Head – for fixed applications	Sandblasted and acid etched
	Classic MDI™ Implants MAX Thread Design	2.4 mm				
	Collared MDI™ Implants Standard Thread Design	1.8 mm, 2.1 mm (O-Ball Prosthetic Head) 1.8 mm (Square Prosthetic Head)				
	Collared MDI™ Implants MAX Thread Design	2.4 mm				
	Hybrid Implant	2.9 mm				
Bicon Dental	Integra-CP	3.0 mm	8 mm	Fixed and removable denture	Shouldered, non-shouldered	Hydroxyapatite coated (HA) and acid etched
Zimmer	ERA mini dental implants	2.2 mm, 3.25 mm	10, 13, 15 mm	Overdentures	None	Acid etched with tapering screw
Implant Direct	ScrewDirect, ScrewIndirect, GoDirect	3.0 mm	8, 16 mm	Fixed and removable denture	Angled, custom-castable, straight	Sand blasted with hydroxylapatite particles and acid washed: Soluble blast media (SBM)
Intra lock	Mini Drive-Lock	2 mm, 2.5 mm	10, 11.5, 13, 15, 18 mm	Overdenture prosthetic and Cement-Over abutments for crown and bridge	Straight, angled, wide, castable, healing	OSSEAN: Enhancing bioactivity with a new calcium phosphate-molecular impregnated implant surface
	Long Collar	2.5 mm				
	Provisional	2 mm, 2.5 mm	13 mm			NON-OSSEAN
	MILO	3 mm	10, 11.5, 13, 15, 17 mm			No information
Hiossen	2.5 mm, 3.0 mm	10, 13, 15 mm	Crown and overdenture	Cement restoration or o-ring attachment	Resorable blast media	
Simpler Implants	2.5 mm	10, 13, 15, 18 mm	Overdentures and Bar supported overdentures	Cement restoration or o-ring attachment	Hydroxyapatite (HA) and grit blasted, acid etched	
KAT Implants	2.5 mm, 3.0 mm	10, 12, 14 mm	Removable and fixed prosthesis	No information	Aluminum oxide blasted	
OCO Bio-medical	I-Micro	2.2 mm, 2.5 mm	10, 12, 14 and 16 mm	Fixed and Removable	Crown and Bridge or O-Ball Attachment Head	Machined, textured and acid-etched
	I-Mini	3.0 mm				
American Dental Implant	2.4 mm	10, 11.5, 13, 16 mm	Removable dentures and overdentures	Straight, zirconia, angled, flared	Micro porous texture, Hydroxyapatite (HA) coated	

gration before placing conventional implant or to secure temporary bridges due to the small ball on the top of these implants (4). However, practitioners have found that 50% of those implants are hard to remove due to integration with the bone during the interim service period, so the implant design was improved to fit with the rules of the osseointegration and the insertion protocol was changed to give stability for immediate occlusal loading (4), leading to possibility of using them in permanent prostheses. After this had been found, the SDI and MDI have been approved for long-term use in 1997 by the FDA (8) resulting in avoiding bone augmentation or enlarging the mesiodistal space and giving the opportunity for more patients with severe cases to gain implant therapy. Conventional implants appeared problematic in: small space between the teeth in the place implant was supposed to be placed, in areas in which bone resorption had occurred, in cases where edentulous arches were with minimal bone in

a facial-lingual or mesiodistal direction, that could lead to excluding such patients from treatment (8). In order to place dental implant in partially edentulous patients, it has been recommended to maintain 2 mm to 3 mm of available space between the surface of the implant and the residual dentition to avoid impinging or damaging the periodontal ligaments of the adjacent teeth (9).

There are many available MDI and SDI implants in today's market. Some of the implant systems (3M ESPE IMTEC, Bicon Dental, Zimmer, Implant Direct, Intra lock, Hiossen, Simpler Implant, KAT Implants, OCO Biomedical, American Dental Implant) are summarized (Table 1).

CONTEMPORARY USE OF MDI AND SDI

The MDI and SDI are indicated for replacement of the teeth in a narrow ridge (10), removable full or partial denture stabilization using multiple implants

Table 2. MDI and SDI survival rates (continued on p. 42)

Citaton	Implant company	Implant diameter, mm	Implant length, mm	Number of implants	Implantation area	Type of prosthesis	Number of failed implants	Follow up duration	Survival rate
Bulard et al. (2005) (5)	IMTEC	1.8-2.4	NS	1029	Mandible	Overdentures	103	4 months to 8 years	91.17%
Comfort et al. (2005) (7)	Brane-mark	3.3	10, 13, 15	23	6 Anterior maxilla, 17 Posterior	Fixed and complete dentures	1	5 years	96%
Shatkin et al. (2007) (18)	3M	1.8-2.4	NS	2514	50% Mandible 50% Maxilla	45% Overdentures 55% Fixed	145	2.9 years	94.20%
Vigolo et al. (2000) (19)	3i	2.9	8.5, 10, 13, 15	52	29 Maxilla 23 Mandible	Single fixed	3	5 years	94.20%
Griffitts et al. (2005) (24)	IMTEC	1.8	10-18	116	Anterior area of mandible	Overdentures	3	5 months	97.40%
Zarone et al. (2006) (25)	ITI	3.3	9, 12, 14	34	Anterior area of maxilla	Fixed	0	24-39 months	100%
Elsyad et al. (2011) (26)	IMTEC	1.8	12, 14, 16, 18	112	Mandible	Overdentures	4	3 years	96.4%
Ahn et al. (2004) (27)	IMTEC	1.8-2	13, 15, 18	27	Mandible	Overdentures	1	5.5 months	96.30%
Hallman et al. (2001) (28)	ITI	3.3	8, 10, 12	160	Maxilla	Various fixed	1	1 year	99.4%
Romeo et al. (2006) (29)	ITI	3.3	10, 12	122	Mandible (66) Maxilla (56)	Single and partially fixed.	3	7 year	96.9% (Mandible) 98.1% (Maxilla)
Sohn et al. (2011) (30)	Biohorizons	3.0	12, 15	62	8 Maxilla 54 Mandible	Fixed	0	23±4.3 months	100%

in mandible and maxilla (4, 5), as well as the sole support for single-tooth replacements in the bone areas less than 6mm in a facial-lingual orientation and 10mm in a crestal-apical orientation (4). MDI and SDI are causing less health challenges by extensive surgical procedures being avoided, are offering the lower cost and can be acceptable for patients with less economical capabilities.

Solidly stable denture can be immediately placed after placement of implants (11, 5), which makes the treatment with SDI and MDI advantageous. Stabilized dentures give improved comfort, chewing ability and speech, in comparison with unstabilized dentures (16, 17).

It also gives the ability to apply less invasive surgical procedures when there is circumferential bone deficiency around the implants (5, 12). The

procedure is less time consuming, bleeding is minimal, implant placement is expedited, and there is no need to place and remove sutures (3, 13), which leads to decreased postoperative discomfort (14) and shortened healing time (13, 15). The reduced amount of bone loss and reduced severity of peri-implant ridge resorption are also one of the MDI and SDI characteristics (12, 16).

MDI and SDI can be compared to conventional implant systems. MDI and SDI are made of one piece; however, conventional implants usually consist of two parts (the implant and the abutment). MDI and SDI have one piece titanium screw with a ball shaped head for denture stabilization or square prosthetic head for fixed applications (Table 1), instead of the classic abutment. MDI and SDI are protruded over the gum surface when they

Table 2. MDI and SDI survival rates (continued from the p. 41)

Citaton	Implant company	Implant diameter, mm	Implant length, mm	Number of implants	Implantation area	Type of prosthesis	Number of failed implants	Follow up duration	Survival rate
Yaltirik et al. (2011) (31)	Straumann	3.3	10, 12, 14	48	31.25% Maxilla 68.75% Mandible	8 for single crown restoration 40 supported fixed partial bridges	3	60 months	93.75%
Zinsli et al. (2004) (32)	ITI	3.3	8, 10, 12	298	43% Maxilla 57% Mandible	120 overdentures 57 fixed	9	6 years	96.60%
Vigolo et al. (2004) (33)	3i	2.9 3.25	8.5, 10, 11.5, 13, 15	192	60% Maxilla 40% Mandible	94 single fixed 98 partial	9	7 years	95.30%
Anitua et al. (2008) (34)	BTI	2.5 3.0 3.3	8.5, 10, 11.5, 13, 15, 18	911	53% Maxilla 47% Mandible	Fixed Overdentures	9	28 months	
Degidi et al. (2009) (35)	XIVE	3.0	13, 15	60	Anterior Maxilla	Single fixed	0	3years	100%
Malo et al. (2011) (36)	Brånemark	3.3	10, 11.5, 13, 15	247	144 posterior Maxilla 103 posterior Mandible	Fixed	12	5 years	95.10%
Anitua et al. (2010) (37)	Tiny	2.5 3.0	10, 11.5, 13, 15	89	66 Maxilla 23 Mandible	30% overdentures 70% Fixed	1	3 years	98.90%
Andersen et al. (2011) (38)	3i	3.25	13, 15	32	Anterior maxilla Mandible	Singe fixed Overdentures	2	2 years	93.80%
Morneburg et al. (2008) (39)	Micro-plant	2.5	9, 12, 15	134			6	6 years	95.50%
Reddy et al. (2008) (40)	Biohorizons	3.0	NS	31	Maxilla Mandible	Single fixed	1	1 year	96.70%
Cho et al. (2007) (41)	Dentatus	2.4	7, 10, 14	34	Mandible	Overdentures	2	14-36 months	94%

are placed into the bone; conventional implants are placed under the gums.

MDI AND SDI SURVIVAL RATES

The studies (Table 2) showed various survival rates of MDI and SDI in short and long term, supporting fixed and partial restorations and overdentures. Cumulative survival rates ranged between 91.17% and 100% in a follow up of 4 months to 8 years. In mandible, osseointegration classically requires 3 to 6 months, while in the maxilla osseointegration takes more time which is 6 to 9 months. The average of all failed implants was around 6.4 month, which shows that the risk of failure of an implant is unlikely to be present after 6 months, so 6 months is a landmark for failure stability (18). The failures were related to poor bone quality in the recipient site, occlusal problems and excessive implant loading due to direct loading on implants (19). No survival rate differences were shown between men and women (18). The really high survival rates were in the short term studies, while smaller survival rate percentages were shown on longer term studies.

DISCUSSION

After extraction of a natural tooth, the space gets smaller in the mesiodistal direction because of movement of neighboring natural teeth toward this space (20). It is possible to put a fixed partial denture or to regain the lost space by orthodontic treatment which is a long duration and high-cost treatment, but since some patients do not want to have their teeth prepared for a fixed partial denture nor willing to pay for orthodontic treatment, implants with a diameter smaller than that of traditional implants are required (19). A 5-year clinical observation of narrow platform implants yielded 96% survival rate in which the implants were placed in patients with buccal-lingual alveolar ridge dimension is at or below 5.0 mm or when the interradicular space is <6mm (7). Flapless technique can be used since no negative influence on implant survival has been reported in case of flap elevation or flapless technique saving the fear of surgery for many patients (12). In comparison with a study reporting the effect of loading on conventional implants retaining overdentures (11), another study showed that mini-implants have

no remarkable harm on the bone after immediate loading directly after surgery (21). Primary stability of small diameter and mini-dental implants showed sufficiency for immediate loading, they can be used as an alternative to treatment with fixed partial dentures in terms of both clinical and aesthetic criteria, as well for retention of complete maxillary and mandibular overdentures (20). Smaller diameter implants are preferred rather than conventional ones for reasons of blood supply, that is, conventional implants may disturb the blood supply to the bone around the implant (22). Additionally, if there is adequate space and an unforeseen bone density or site inadequacy is encountered during the osteotomy of a small-diameter implant, the use of a slightly larger-diameter implant that is able to attain better initial stability stays an option (23) Since edentulous patients with highly atrophied bone have deficiency in masticatory function due to bad stabilization of the dentures, leading to malnutrition, but after stabilizing the dentures with implants, this will lead to a more efficient mastication helping for better absorption of nutrients in the further steps following the complete mastication of food, decreasing the risk of malnutrition (23). Finally, these implants are relatively affordable providing excellent satisfaction for patient and providing high reliability in comparison with conventional diameter implants (24, 25).

CONCLUSIONS

Implants with small diameters are one of the major advancements in dental history; they can be used successfully in a variety of clinical situations. Researches continue to demonstrate the surgical and prosthodontic success of those implants. They offer patients satisfaction due to less surgical time, less postoperative pain and ability of direct loading after surgery with no harm to bone. Also they are more cost effective option, since they can support a denture with a reduced cost. It must be emphasized that the reduced surface implants require correct treatment planning so that the loading force would not cause bone loss or implant failure. Nevertheless, MDI and SDI showed high survival rates, but special cautions of bone quality and good oral hygiene should be maintained. Due to simplified procedures, this could be a good choice for unexperienced dentists for their first steps in implantology.

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