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The Success Rate of Narrow Body Implants Used for Supporting Immediate Provisional Restorations: A Pilot Feasibility Study

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Background: *Implants were first designed to be used in the reconstruction of edentulous mandibles. However, with the technological advancement, enormous changes were made to improve the implant design and surface characteristics leading to the wide use of implants in the replacement of missing teeth. During the transition from an edentulous span to a fixed prosthesis, narrow body implants (NBIs) have been proposed to enhance patient comfort and function. Therefore, this study was aimed at investigating the survival and success rates of NBIs used for supporting immediately nonfunctional loaded provisional fixed partial denture (PFPD).*

Methods: *Either 2.2- or 2.4-mm-diameter dental implants were placed transmucosally into the edentulous ridges of 10 partially edentulous patients. PFPD of self-cured bis-acryl composite material were made using either a vacuform template chairside or a relined prefabricated PFPD. Occlusal adjustments were made to ensure that there was no functional loading on the provisional restorations before they were secured onto the transitional implants.*

Results: *At 1 year, the implant success and survival rates were 38.7% and 93.5%, respectively, with a mean percentage of bone loss of 9.46% (0%–40%) and a mean bone loss of 1.19 mm (range: 0–3.5 mm).*

Conclusions: *With a favorable implant survival rate, the use of NBIs to support provisional restorations seemed to be a feasible treatment option. In addition, there is merit for research on the long-term use of NBIs-supported final prostheses. (Implant Dent 2012;21:467–473)*

Key Words: dental implants, success rate, narrow diameter, small diameter, immediate provisionalization

Implants are originally designed to help in the prosthetic rehabilitation of edentulous mandibles[1] because tooth loss leads to volumetric resorption of the alveolar ridge,[2,3] resulting in a flat or slightly raised ridge which is inadequate to retain and stabilize a removable partial denture (RPD) firmly during the function.[4] In addition, the lack of adequate ridge width and height creates challenges in restoring the edentulous ridges with implant-supported prostheses. Henceforth, hard and soft tissue augmentation techniques are needed to create a site appropriate for implant placement.[5–7] Although the available augmentation techniques are able to facilitate ideal implant placement, they are after all additional surgical procedures that bring about an increase in cost, level of discomfort, and duration of treatment.

The advent of narrow diameter implants (<3.75 mm wide) may be the solution for receiving implant-supported prostheses without the need for advanced bone grafting procedures. They may also be used as transitional implants to allow for undisturbed healing of the implant surgical site while providing the patient with function and aesthetics during the healing phase.[8–10] Recent data on narrow diameter implants (≤3.5 mm diameter) for fixed dental prostheses demonstrated a 12-year cumulative implant survival rate of 98.1% with an annual mean marginal bone loss of 0.07 ± 0.20 mm.[11] Morneburg and Proschel[12] reported, after 6.0 ± 2.7 years, a 95.5% survival

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rate when 2 narrow diameter (2.5 mm) implants were used to support an overdenture. Mazor et al[13] and Froum et al,[14] in separate case series, showed almost 100% survival rates of the narrow diameter implants (1.8–2.4 mm). So far, limited evidence is available regarding the success and survival rates of using narrow diameter implants (specifically 2.2–2.4 mm) in supporting prostheses either transitionally or permanently. The aim of this study was thus to report the success and survival rates of narrow body implants (NBIs) used for supporting immediately nonfunctional loaded provisional fixed partial dentures (PFPDs).

MATERIALS AND METHODS

Study Population

After obtaining approval from the University of Michigan Human Subject Review Committee, patients seen at the University of Michigan, School of Dentistry, were screened for this study. This study was conducted between January 2008 and May 2009. Those who met the inclusion criteria were invited to participate in the study. The study included patients who were 21 years old or more, missing 2 or more teeth, and required the use of narrow diameter implants, for example, aesthetic region or bone augmentation during the course of the implant therapy. Besides being compliant to the research protocol, these patients would also have agreed to a definitive restorative treatment plan customized to their needs by a restorative dentist. Patients who were medically compromised, for example, heavy smoking, uncontrolled diabetes, osteoporosis, history of head and neck radiation therapy and extensive oral rehabilitation cases, were excluded from the study. Ten patients, 5 males and 5 females, of a mean age of 55.3 years (55.3 ± 10.1 years), were recruited, and informed consent forms were signed before they were randomly assigned into 2 groups. Randomization was done by picking a number card out of a bag; patients who picked the card marked "1" was assigned to group 1, whereas those who picked the card marked "2" was assigned to group 2. Five patients (group 1) received a prefabricated provisional restoration, whereas the other 5 patients (group 2) received a chairside-fabricated provisional restoration.

Clinical Parameters

The width of keratinized gingiva (KG) and its thickness at 2.0 mm below the free gingival margin were measured using a 15-mm University of North Carolina probe (UNC-15 probe; Hu-Friedy, IL), to the nearest 0.5 mm by a calibrated examiner (MGL). Assessment of the oral hygiene status of the patients was made using the modified plaque index[15] and the modified bleeding index (mBI)[15] at 7 different time points—baseline, 2 weeks, 1, 2, 3, 6, and 12 months postimplant placements.

In addition, customized radiographic holders (Rinn CP, Dentsply Rinn, Elgin, IL) were used to take standardized radiographs of the implant-treated sites at 4 different time points—baseline, immediately after implant placement, and 6 and 12 months after implant placement. All periapical radiographs were scanned and magnified 10 times using a computer software (Adobe Photoshop 2008; Adobe Systems Incorporated; San Jose, CA). Radiographic bone levels were measured from the mesial and distal edges of the implant platform to the most coronal edge of the bone crest using a graduated scale, rounding off to the nearest 0.5 mm. The bone level measured right after implant placement was used as the reference level to determine the amount of bone loss that occurred with time. All measurements were performed by the same calibrated examiner (KO). The percentage of bone loss that occurred was calculated by dividing the distance measured over the length of the implant in bone right after placement and multiplied by 100%.

Surgical Procedure

All patients were given antimicrobial prophylaxis of 2.0 g amoxicillin 1 hour before the surgical procedure. A crestal incision was made with a blade no. 15c scalpel after the edentulous site was anaesthetized with local infiltrations of 2% lidocaine, 1:100,000 epinephrine solution. A full thickness mucoperiosteal flap was elevated, and the width of the underlying ridge crest was determined. Customized surgical templates were used to guide the osteotomy site preparations for the placement of implants (either 2.2 or 2.4 mm in diameter). Under copious sterile water irrigation, a 1.3-mm-wide twist drill running at 1500 to 2000 revolutions per minute was used to make the osteotomy site preparation perpendicular to the ridge crest. The angulations of the implants were checked radiographically before their placement. Using a manual snap-in driver or a handpiece driver turning at 30 revolutions per minute, the implants were inserted into their ideal positions with maximum initial implant stability. All implants were stable and immobile before flap closure was performed. The

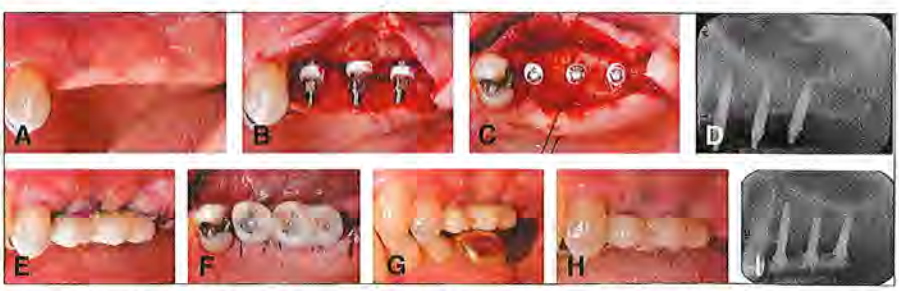

Fig. 1. Implant placement and provisionalization **A**, Preoperative site. **B**, Buccal view of the NBIs (ANEW; Dentatus; 2.4 × 10 mm and 2.4 × 7 mm) placed with primary stability in the alveolar bone. **C**, Occlusal view of the NBIs before provisionalization. **D**, Standardized periapical radiograph of the implants taken right after placement. **E**. Buccal view of the PFPD inserted on the NBIs. **F**, Occlusal view of the PFPD inserted on the NBIs. **G**. Buccal view of the PFPD at the 1-month follow-up visit. **H**, Buccal view of the PFPD at the 12-month follow-up visit. **I**, Standardized periapical radiograph of the provisionalized NBIs at the 12-month follow-up visit.

surgical site was subsequently closed with 4.0 Vicryl sutures (Ethicon, Johnson & Johnson; New Jersey, NJ). All surgeries were performed by one surgeon (HL), who also determined the bone density of the edentulous site using the classification by Lekholm and Zarb.[16]

A titanium index coping was fitted over the implant platform, and a gray screw cap was placed securing the coping to the implant. Brass plugs were placed into the open end of the screw cap to prevent provisional resin material from flowing into the screw hole. Patients in group 1 received a prefabricated PFPD made of self-cured bis-acrylic composite material (ProTemp 3 Garant; 3M ESPE, MN). The provisional restoration was relined with provisional bis-acrylic composite material to ensure a better fit to the implant platform. Chairside provisionalization using the same self-cured bis-acrylic composite material and vacuform templates was done for patients in group 2. Both the templates and prefabricated PFPD were made from a full-contour wax-up model. Occlusal adjustments were made to ensure that the provisional restorations were not in functional occlusal loading during centric occlusion or lateral excursive movements before being secured onto the implant platform with a screw.

Patients were prescribed 600 mg of Ibuprofen 3 times a day for 5 days to cope with the postsurgical discomfort. They were instructed on oral hygiene measures and also to have a soft diet for the first 4 weeks of healing. Patients were subsequently seen for 6-monthly recall appointments.

Implants Placed

A system of narrow body dental implants (ANEW; Dentatus, New York, NY) developed for screw-retained restorations was used in this study. Twenty-five 2.4-mm-wide implants and six 2.2-mm-wide implants were inserted in the 10 patients. Patients in group 1 had a mean of 4.4 implants (range: 3–7) placed while patients in group 2 had a mean of 2.8 implants (range: 2–3). The implant lengths ranged from 7, 10, and 14 mm. Nearly half, 51.5% (15 of 31) of the implants were placed in type III bone, whereas the remaining 48.5% of the implants (6, 6, and 4 implants, respectively) were placed in type I, II, and IV bone. All implants had primary stability during the initial placement.

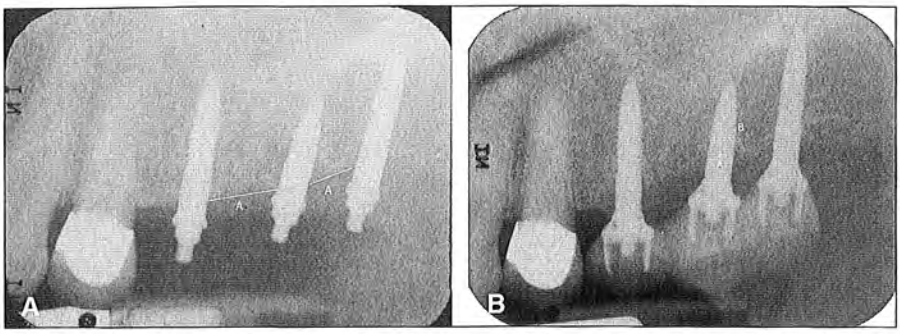

Fig. 2. Radiographic assessment of bone levels around the implants. **A**, Periapical radiograph of the implants taken right after placement. The level of smooth and first screw junction was labeled as "A," and this is the reference for future bone level. **B**, Periapical radiograph taken of the provisionalized NBIs at the 12-month follow-up visit. The label "A" represents the junction of smooth and first screw (the level of bone after remodeling) and label "B" indicated actual current bone level. The amount of bone loss was calculated at 1 year by subtraction of B from A.

Table 1. Baseline Characteristics of the 2 Groups

Variable	Overall ($N = 10$)	Group 1 ($N = 5$)	Group 2 ($N = 5$)	P
Gender				
Male	5	4	1	0.21
Female	5	1	4	
Mean age (SD)	55.3 (10.1)	59.4 (11.2)	51.2 (7.8)	0.25
Variable	**Overall ($N = 31$)**	**Group A ($N = 16$)**	**Group B ($N = 15$)**	**P**
Number of implants				0.09
2	2	2	0	
3	7	4	3	
6	1	0	1	
Modified bleeding index				>0.99
0	28	14	14	
1	3	2	1	
Keratinized gingiva width Mesiobuccal	5.4 (2.5)	6.3 (2.1)	3.9 (2.4)	0.01
KG thickness 2 mm below gingival margin	2.1 (1.0)	2.6 (0.8)	1.3 (0.9)	<0.01
Fixture diameter				0.66
2.2	6	3	3	
2.4	25	13	12	
Fixture length				0.20
7	3	2	1	
10	18	7	11	
14	10	7	3	
Primary stability				
1	31	16	15	
Bone density				0.03
I	6	5	1	
II	6	0	6	
III	15	8	7	
IV	4	3	1	

KG, keratinized gingiva.

Table 2. Summary of Studies on Narrow Diameter Implants (<3.0 mm)

Authors/Year	No. of Patients	No. of Implants	Implant Diameter	Implant Type	Prosthesis Type	Location	Follow-Up Period	Marginal Bone Loss	Survival Rate	Failure Rate %
Polizzi et al[34]	21	30	3.0 mm	Branemark	Single crown	Maxilla and mandible	3–7 y (mean 5.25 y)	During the first year of function: <1 mm—22 implants >1 mm—2 implants Unreadable—6 implants	96.7% success rate	3.3
Vigolo et al[35]	44	52	2.9 mm	3i	Single crown	Maxilla and mandible	5 y	0.8 mm Range 0.5–1.1 mm at 5 y follow-up	94.2%	5.8
Mazor et al[13]	32	32	2.4 mm	Hi-Tec	Single crown	Maxilla and mandible	5 y	—	96.9%	3.1
Vigolo et al[36]	165	192: 100–2.9 mm 92–3.25 mm	2.9 mm 3.25 mm	3i	Single crown Fixed partial denture	Maxilla and mandible	7 y	0.8 mm Range 0.5–1.2 mm at 7 y	95.3%	4.7
Griffitts et al[37]	24	116	1.8 mm	Sendax IMTEC	Overdentures	Mandible	—	—	97.4% success rate	2.6
Froum et al[14]	27	48	1.8, 2.2. 2.4 mm	ANEW	Single crown	—	1–5 y	—	100%	0
Shatkin et al[33]	531	2514	1.8–2.4 mm	—	Single crown Fixed partial denture Overdenture	Maxilla and mandible	5 y	—	94.2%	5.8
Morneburg et al[12]	67	134	2.5 mm	Sandblasted and calcium phosphate coated	Overdenture	Mandible	6 ± 2.7 y	0.5 mm ± 0.4 mm in first y. 0.7 ± 0.3 mm in the second y. No significant resorption thereafter.	95.5%	4.5
Reddy et al[30]	17	31	3.0 mm	BioHorizons	Single crown	Maxilla and mandible	1 y	0.58 mm between 0 and 6 mo. 0.12 mm between 6 and 12 mo.	96.7%	3.3

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Table 2. (Continued)

Authors/Year	No. of Patients	No. of Implants	Implant Diameter	Implant Type	Prosthesis Type	Location	Follow-Up Period	Marginal Bone Loss	Survival Rate	Failure Rate %
Degidi et al[38]	60	60	3.0 mm	Grit-blasted acid-etched	Single crown	Maxilla	3 y	0.85 ± 0.71 mm (immediate loading) 0.75 ± 0.63 mm (1 stage)	100%	0
Degidi et al[39]	40	93	3.0 mm	Grit-blasted acid-etched	Single crown Fixed partial denture	Maxilla and mandible	4 y	1.16 ± 0.9 mm	100%	0
Elsyad et al[40]	28	112	1.8 mm	Sandblasted acid-etched	Overdenture	Mandible	3 y	1.26 ± 0.64 mm at 3 y follow-up	96.4% Success rate is 92.9%	3.6

Figure 1, A to I illustrate the research methodology from implant placement and provisionalization to the 1-year radiographic follow-up. Figure 2, A and B illustrate the changes in bone levels around the implants.

Statistical Analysis

Fisher exact and Wilcoxon rank sum tests were used to analyze the categorical and continuous variables between the 2 groups, respectively. The significance level was set at $P = 0.05$.

RESULTS

Table 1 illustrating results from the Wilcoxon rank sum test showed that there were no significant differences ($P > 0.05$) between the 2 groups in terms of the age and gender of the patient population, the number of implants placed, the fixture diameters, and lengths used. However, there was a significant difference in the baseline bone density of the ridge, the width of KG, and its thickness at 2 mm below the free gingival margin ($P < 0.05$). All implants were stable during the course of the study.

Of the 31 implants that were placed in the 10 patients, 12 implants had no bone loss, 17 implants had less than 25% bone loss, and 2 implants had 25% to 50% bone loss at 1 year. The overall mean percentage bone loss was 9.46% (0%–40%) with a mean bone loss of 1.19 mm (range: 0–3.5 mm). There was no significant difference in implant stability with both groups reporting 100% stability from the 2-month follow-up onwards. No event of implant complication was reported during the course of the study.

At 1-year follow-up, the implant success rate was calculated to be 38.7%, whereas the survival rate was 93.5% with 2 implants lost (1 from each group) of the 31 implants that were placed. The implants were removed, 1 at 2 weeks post-insertion because of premature loading (eg, chewing the peanut) and the other at 3 months because of lateral occlusal overload (eg, biting chicken and fracture the whole prosthesis).

DISCUSSION

Recent data have shown that only 20% of edentate patients have dental implants to replace their missing teeth.[17] Besides the hefty price associated with dental implants, the fear of failure or complications[18] and additional pain[19] deterred most patients from seeking implant-supported prostheses. Although augmentation of a residual ridge to facilitate ideal implant positioning[20] was shown to be a predictable procedure,[21,22] however, it is not risk free,[23] eg, barrier membrane exposure, reduction in bone regeneration, postsurgical infection, etc. The use of NBIs may allow clinicians to avoid the need for bone grafting procedures. In addition, they can be used to provide immediate provisionalization, protection of the implant or augmented sites, and prevention of premature implant loading.[13]

In this study, most of the NBIs were placed into type III bone and in areas with thicker KG. This is different from the report by Misch,[24] where the immediately loaded implants were placed in denser bone, for example, in the interforaminal region of the mandible. Thus implying that these implants may be feasible in less dense bone.

The survival rates of narrow diameter implants were shown to be promising by several studies.[12–14,25,26] Mazor et al[13] placed thirty-two 2.4-mm-wide implants in edentulous ridges that were at most 4-mm-wide facial-lingually and mesiodistally. These implants were immediately loaded with provisional crowns and followed up clinically and radiographically for up to 5 years. One implant failed because of mechanical overload and was removed, leading to an overall implant survival rate of 96.9%. Froum et al[14] placed 48 narrow diameter implants (1.8–2.4 mm in diameter), which were immediately provisionalized, in 27 patients. All implants were followed up for up to 5 years. There were no implant failures hence the authors reported an overall implant survival rate of 100%. However, the authors did not report on the bone loss, if any, around these implants. Degidi et al[25] conducted a retrospective study on 510 implants (3.0–3.5 mm wide) inserted in 237 patients. They found that these implants had a survival rate of 99.4% at the end of a mean follow-up period of 20 months. Franco et al[26] conducted a similar study with 91 narrow diameter implants (3.0–3.5 mm wide) inserted into 36 patients. Five of the implants failed within 25 months thus giving an implant survival rate of 95.7%. Morneburg and Proschel[12] placed two 2.5-mm-wide implants in the interforaminal area of 67 edentulous mandibles. The implants were observed for 6.0 ± 2.7 years, and a cumulative survival rate of 95.5% was obtained. A recent review demonstrated that small diameter implants had a similar survival rate as standard diameter implants, ranging from 95% to 100%. However, it seemed that implant lengths of ≤13 mm had more failures compared with implants that were >13 mm long.[27]

In our study, 93.5% of the implants survived the first year of function. Two of the implants were removed because they were mobile due to premature loading and lateral occlusal overload. An overall mean percentage marginal bone loss of 9.46% was found, and this can be translated to a mean bone loss of 1.19 mm of marginal bone loss depending on the length of the implant placed. This amount of marginal bone loss is well within the implant success criteria proposed by Albrektsson et al[28] and Smith and Zarb.[29]

A study by Reddy et al[30] found a mean bone height reduction of 0.7 mm at 1 year for 3.0-mm-diameter implants. Their findings were slightly reduced compared with the 1.19-mm mean marginal bone loss encountered in our study, and this may be because of the different implant systems and a larger diameter of the implant (3.0 mm vs 2.2–2.4 mm in our study) used. In a histological evaluation of the performance of narrow diameter implants, the percentage of bone-to-implant contact (52.9% ± 13.81%) was found to be similar to that of the conventional machined surface implants in a after mean follow-up duration of 10.8 months.[31] Hence providing evidence of the osseointegration of these narrow diameter implants. A multi-centered study, involving 5 centers, examined 1029 narrow diameter implants (1.8–2.4 mm). Of these implants, 8.83% failed, resulting in an overall success rate of 91.2% over a period of 5 to 8 years.[32] Shatkin et al,[33] in a retrospective study, examined 2514 narrow diameter implants (1.8–2.4 mm) in 531 patients for a mean follow-up duration of 2.9 years. The overall implant survival rate was 94.2%, which was comparable to our 1-year results. The authors also found that the use of removable prostheses, the quality of bone, and smoking were the significant predictors of implant failure, which occurred in an estimated period of 6.4 months. Table 2 illustrates a summary of studies on narrow diameter implants (<3.0 mm).

Therefore, the authors believe that the NBIs can be successfully used to support implant-supported provisional restorations. These implants may be a feasible treatment option, if proven to sustain occlusal load and maintain their long-term stability, in the rehabilitation of edentulous ridges.

CONCLUSIONS

The use of NBIs in areas of deficient bone volume may be a promising treatment option. Not only will it reduce the complexity of the implant treatment, it will also provide patients with the benefits associated with implant-supported restorations.

DISCLOSURE

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

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