Influence of the Diameter of Dental Implants Replacing Single Molars: 3- to 6-Year Follow-Up

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Purpose: *The aim of this study was to evaluate the influence of the implant diameter on marginal bone remodeling around dental implants replacing single molars after a follow-up period of 3 to 6 years.* ***Materials and Methods:*** *Patients who received dental implants with an external hexagon platform in healed sites to support a single metal-ceramic crown in the molar region were recalled to the office. The implantation sites and implant length information were recorded, and the implants were divided according to the implant diameter: regular (RP) or wide (WP). Each implant was assessed by digital periapical radiography, using a sensor holder for the paralleling technique. The marginal bone remodeling was determined as the distance from the implant platform to the first bone-to-implant contact, and the known implant length was used to calibrate the images in the computer software. The follow-up measurements were compared with those obtained from the radiograph taken at the time of prosthetic loading to determine the late bone remodeling. The independent t test was used to compare data.* ***Results:*** *A total of 67 implants from 46 patients were evaluated with a mean follow-up period of 4.5 ± 1.0 years. The RP group comprised 36 implants from 29 patients (mean age: 58.3 ± 10.6 years), while 31 implants from 17 patients (mean age: 56.9 ± 11.5 years) were included in the WP group. The RP group presented lower survival rates (86.1%) than the WP group (100.0%). Similar marginal bone loss ($P < .05$) was identified for the RP and WP groups (1.35 ± 0.96 mm and 1.06 ± 0.70 mm, respectively).* ***Conclusion:*** *Although wide-diameter implants exhibited lower incidence failures, the bone levels were similar after the prosthetic loading around regular- and wide-diameter implants supporting single molar crowns.* Int J Oral Maxillofac Implants 2017;32:1111–1115. doi: 10.11607/jomi.5234

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The use of dental implants to replace single posterior teeth has become a predictable treatment that allows the preservation of the adjacent teeth.[1] However, the success rates of these implants are usually lower than those of implants placed in the anterior region.[2,3] Some anatomical and biomechanical factors of the posterior region of the arches may limit implant success, such as limited bone height due to the presence of maxillary sinus or alveolar nerve associated with poor-quality bone and higher occlusal load.[4] Thus, adequate implant selection may be significant for the long-term success of single molar replacement.[5]

Regular-diameter implants supporting single molars were associated with a higher incidence of loosening screws and screw or implant fractures,[6] probably due to the bending forces and titanium fatigue.[5] However, most implants nowadays are manufactured from titanium grade,[4] which is a stronger alloy, to minimize implant fractures. Indeed, a more recent publication using adequate surgical preparation, new implant designs, and surfaces has demonstrated no relationship between survival rate and implant diameter.[7]

The use of single wide-diameter implants can provide a greater surface area and reduced stresses in the crestal cortical than one regular-diameter implant,[8,9] especially for residual ridges with minimal height at the posterior region.[10] However, it is unknown if wide implants are more susceptible to bone loss than regular-diameter implants in the posterior region.

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Although the engagement into buccal and lingual cortical walls favors a better primary stability for wider implants,[5] these require sufficient bone at the buccolingual dimension that can limit their application or require bone augmentation procedures.[11,12] Thus, the aim of this retrospective study was to evaluate the survival rate and the marginal bone loss of regular- and wide-diameter implants supporting single molars after a follow-up period of 3 to 6 years.

MATERIALS AND METHODS

Patient and Implant Selection

The present retrospective study was reported following the STROBE guidelines, and it was conducted in accordance with the Helsinki declaration[13] after approval by the São Leopoldo Mandic Dental School Ethical Committee (Campinas, SP, Brazil). Patients with good general health who received at least one single implant at the molar sites without any bone augmentation procedures were selected for this study. Patients with known bruxism or clenching habits or presenting signs of occlusal parafunction were excluded.[14] Smokers and those who did not present natural or fixed opposing teeth were also excluded. All selected patients signed an informed consent.

The implants selected were from the same manufacturer (Nobel Biocare) and same design (Brånemark MkIII implant model), presenting the same anodized surface treatment and external hexagon implant-abutment connection. The implants were divided into two groups according to the implant diameter: regular (RP) or wide (WP) implants.

Surgical and Restorative Procedure

All surgeries were performed by the same surgeon (J.A.M.). A unique 2 g dose of amoxicillin (or 600 mg clindamycin for patients with penicillin allergy) was administrated orally 1 hour prior to surgery to prevent postoperative infections.[15] To control swelling and postoperative pain, 600 mg ibuprofen was used for 3 days since it does not affect the marginal bone around dental implants in the early healing period.[16]

The alveolar ridge was exposed by a full-thickness flap under local anesthesia, osteotomy was performed following the manufacturer's instructions, and the implants were placed at the crestal level. The implants were loaded after 12 to 18 weeks of submersed healing. Single metal-ceramic crowns were provided for each implant, preferably with screw retention; however, cemented crowns were used when the occlusal hole for screw access would compromise the integrity of the functional canines. Routine follow-up appointments were performed every 6 months.

Recall Appointment

The recall appointment represented 3 to 6 years of a radiographic follow-up examination. Digital periapical radiographs taken using the long-cone paralleling technique were used to assess the marginal bone levels, and the implant length was used as reference to measure the linear distance from the implant platform to the first bone-to-implant contact.[17] The measurements were performed by an expert investigator (J.A.M.) using image-processing software (UTHSCSA Image Tool for Windows, University of Texas Health Science Center), and the mean from the mesial and distal sides was recorded for each implant. The radiograph taken at the day of prosthetic loading was used as baseline. The difference between the bone level at the baseline and at the recall examination was defined as late bone remodeling. In addition, implantation sites and implant lengths were recorded.

Statistical Analysis

Failure rates were compared using the chi-square test. After checking whether bone loss data were distributed normally with the Shapiro-Wilk test, the data were submitted to square root transformation, and the independent *t* test was used to compare the implant groups at a significance level of 5% (SPSS Version 20, IBM).

RESULTS

Forty-six patients (30 women, 16 men) with ages ranging from 32 to 79 years (mean: 57.8 ± 11.0 years) attended the recall. A total of 67 single implants placed between 2007 and 2010 with a mean follow-up period of 4.5 ± 1.0 years (3 to 6 years) were evaluated. No sensory disturbance was reported following surgeries, and good health around teeth and implants was seen at the recall.

The RP group comprised 36 implants from 29 patients, while the WP group had 31 implants from 17 patients. The sex and age distribution were similar among the patients in both groups (Table 1). The implantation sites are described in Fig 1; 49 implants were placed in the maxilla and 18 in the mandible.

Five (13.9%) failures were recorded in the RP group ($P < .05$; 95% CI: 0.390 to 0.641), distributed into three early failures (8.3%) before loading and two late failures (5.6%) after loading, as shown in Table 2. All RP failures were recorded in the mandible, and no failures were recorded for WP implants.

Late bone remodeling was evaluated in the 62 successful implants (Table 3). Similar values ($P > .05$) were identified around the RP (1.35 ± 0.96 mm) and WP (1.06 ± 0.70 mm) implants.

Table 1 Age and Sex Distribution of Patients Presenting Regular- (RP) and Wide-Diameter (WP) Implants

	RP		WP		Total	
	Patients	Age (y) (mean ± SD)	Patients	Age (y) (mean ± SD)	Patients	Age (y) (mean ± SD)
Men	10	56.1 ± 5.9	6	63.8 ± 8.8	16	59.0 ± 8.1
Women	19	59.5 ± 12.2	11	53.2 ± 11.1	30	57.2 ± 12.2
Total	29	58.3 ± 10.6	17	56.9 ± 11.5	46	57.8 ± 11.0

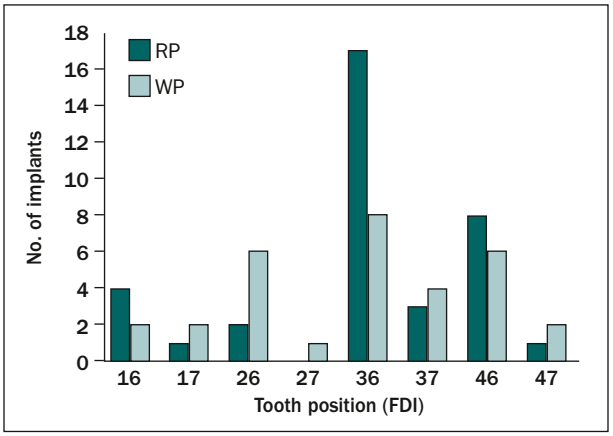

Fig 1 Implant distribution according to the tooth position (FDI tooth-numbering system) in the regular- (RP) and wide-diameter (WP) implant groups.

Table 2 Failure Distribution According to Time of Loading and Implant Length of Regular- (RP) and Wide-Diameter (WP) Implants

				Late failure	
Implant length (mm)	Total	Successful implants	Early failure (before loading)	0 to 6 mo after loading	6 to 12 mo after loading
RP	**36**	**31 (86.1%)**	**3 (8.3%)**	**1 (2.8%)**	**1 (2.8%)**
8.5	6	3 (50.2%)	1 (16.6%)	1 (16.6%)	1 (16.6%)
10	12	11 (91.6%)	1 (8.4%)	0	0
11.5	6	5 (83.4%)	1 (16.6%)	0	0
13	12	12 (100%)	0	0	0
WP	**31**	**31 (100%)**	**0**	**0**	**0**
8.5	5	5 (100%)	0	0	0
10	12	12 (100%)	0	0	0
11.5	4	4 (100%)	0	0	0
13	10	10 (100%)	0	0	0

DISCUSSION

All implants evaluated in the present study were from the same manufacturer to exclude the influence of the implant surface on bone remodeling. In addition, external hexagon platforms and no platform-switching abutments were used to remove the influence of different implant-abutment connections in this outcome.

Although screw-retained restorations are related to fewer technical and biologic complications,[18] the retention system is usually not related to bone stress, and consequently, to bone remodeling.[19] However, it was not possible to control the crown-to-implant ratio, and the present study focused on the influence of implant diameter on bone remodeling around dental implants supporting single molar crowns.

Table 3 Late Bone Remodeling of Regular- (RP) and Wide-Diameter (WP) Implants According to Implant Length and Implantation Site

	Mandible		Maxilla		Total	
Implant length (mm)	n	Bone loss (mm) (mean ± SD)	n	Bone loss (mm) (mean ± SD)	n	Bone loss (mm) (mean ± SD)
RP	**24**	**1.50 ± 0.96**	**7**	**0.82 ± 0.74**	**31**	**1.35 ± 0.96**
8.5	3	0.92 ± 0.31	0	–	3	0.92 ± 0.31
10	9	1.61 ± 1.06	2	0.25 ± 0.00	11	1.36 ± 1.09
11.5	5	1.25 ± 0.69	0	–	5	1.25 ± 0.69
13	7	1.79 ± 1.01	5	1.05 ± 0.76	12	1.48 ± 0.99
WP	**20**	**1.14 ± 0.79**	**11**	**0.93 ± 0.44**	**31**	**1.06 ± 0.70**
8.5	4	1.44 ± 0.94	1	1.50 ± 0.00	5	1.45 ± 0.84
10	6	0.75 ± 0.56	6	0.83 ± 0.37	12	0.79 ± 0.48
11.5	4	1.19 ± 0.92	0	–	4	1.19 ± 0.92
13	6	1.29 ± 0.62	4	0.94 ± 0.48	10	1.15 ± 0.59
Total	**44**	**1.34 ± 0.90**	**18**	**0.89 ± 0.58**	**62**	**1.21 ± 0.85**

Selecting optimal implant sizes, diameter, and length on the basis of bone quality is important for dental implants,[20] especially for load-bearing areas in the posterior region of the arches. When the diameter is increased, the bone-to-implant contact area increases, which provides better implant stability; at the same time, it increases implant strength and fracture resistance.[21] Crestal bone loss around implants is attributed to occlusal load, and it is believed that wider-diameter implants reduce the stress around the crestal bone and potential bone loss. Thus, the optimal diameter would be the largest implant diameter, within morphologic limits, causing minimal stress in the surrounding cortical and trabecular bone.[22] However, the larger-diameter implant is not always the best choice for minimizing cortical bone–implant interface stress.[20]

The success rate in the present study was compatible with others reported previously in the literature.[23–27] However, the regular-diameter group exhibited a lower success rate than the wide-diameter implant group. The absence of early failures in WP can be attributed to the bicortical engagement in the buccal and lingual cortical walls and better stability.[5] Thus, the surgical procedure would be critical for the success of dental implants supporting single molar crowns.

However, the late bone remodeling was similar in both groups after the follow-up period, which indicates that the influence of implant diameter on stress distribution to the surrounding bone may not be clinically relevant. The bone remodeling values were lower in the present study when compared with a previous study[28] since they considered the early bone remodeling using the radiograph taken before implant placement as baseline. Thus, any bone loss after implant placement and before prosthetic loading was not computed in the present study and can be considered a limitation.

In the present study, a higher failure rate was identified in the mandible. This is in accordance with previous studies.[11,14] However, this information is in contrast to a previous study that reported similar short-term implant survival for maxillary and mandibular first molar sites[29] and to another study that reported slightly more failures in the maxilla for wide-diameter implants replacing molars.[30]

Considering the implant length, early failures happened in the shorter implants of the RP group, highlighting the importance of length on implant stability. However, no significant difference was identified between the different diameters when evaluating 8.5- to 13-mm-long implants, which corroborates mathematical results that the length has little influence on bone stress distribution.[20] Future studies should investigate the influence of diameter on other implant-abutment connections or in short and ultrashort implants.

CONCLUSIONS

Although wide-diameter implants exhibited lower incidence failures, the bone levels were similar after prosthetic loading around regular- and wide-diameter implants supporting single molar crowns.

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REFERENCES

1. Rinke S, Roediger M, Eickholz P, Lange K, Ziebolz D. Technical and biological complications of single-molar implant restorations. Clin Oral Implants Res 2015;26:1024–1030.
2. Carvalho W, Casado PL, Caúla AL, Barboza EP. Implants for single first molar replacement: Important treatment concerns. Implant Dent 2004;13:328–335.
3. Shin SW, Bryant SR, Zarb GA. A retrospective study on the treatment outcome of wide-bodied implants. Int J Prosthodont 2004;17:52–58.
4. Greenstein G, Cavallaro J, Tarnow D. Practical application of anatomy for the dental implant surgeon. J Periodontol 2008;79:1833–1846.
5. Levin L, Laviv A, Schwartz-Arad D. Long-term success of implants replacing a single molar. J Periodontol 2006;77:1528–1532.
6. Balshi TJ, Hernandez RE, Pryszlak MC, Rangert B. A comparative study of one implant versus two replacing a single molar. Int J Oral Maxillofac Implants 1996;11:372–378.
7. Renouard F, Nisand D. Impact of implant length and diameter on survival rates. Clin Oral Implants Res 2006;17(suppl):s35–s51.
8. Petrie CS, Williams JL. Comparative evaluation of implant designs: Influence of diameter, length, and taper on strains in the alveolar crest. A three-dimensional finite-element analysis. Clin Oral Implants Res 2005;16:486–494.
9. Ormianer Z, Palti A, Demiralp B, Heller G, Lewinstein I, Khayat PG. Implant-supported first molar restorations: Correlation of finite element analysis with clinical outcomes. Int J Oral Maxillofac Implants 2012;27:e1–e12.
10. Griffin TJ, Cheung WS. The use of short, wide implants in posterior areas with reduced bone height: A retrospective investigation. J Prosthet Dent 2004;92:139–144.
11. Graves SL, Jansen CE, Siddiqui AA, Beaty KD. Wide diameter implants: Indications, considerations and preliminary results over a two-year period. Aust Prosthodont J 1994;8:31–37.
12. Becker W, Becker BE. Replacement of maxillary and mandibular molars with single endosseous implant restorations: A retrospective study. J Prosthet Dent 1995;74:51–55.
13. von Elm E, Altman DG, Egger M, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. BMJ 2007;335:806–808.
14. Schwartz-Arad D, Samet N, Samet N. Single tooth replacement of missing molars: A retrospective study of 78 implants. J Periodontol 1999;70:449–454.
15. Esposito M, Grusovin MG, Worthington HV. Interventions for replacing missing teeth: Antibiotics at dental implant placement to prevent complications. Cochrane Database Syst Rev 2013;(7):CD004152.
16. Alissa R, Sakka S, Oliver R, et al. Influence of ibuprofen on bone healing around dental implants: A randomised double-blind placebo-controlled clinical study. Eur J Oral Implantol 2009;2:185–199.
17. Roos-Jansåker AM, Lindahl C, Renvert H, Renvert S. Nine- to fourteen-year follow-up of implant treatment. Part II: Presence of peri-implant lesions. J Clin Periodontol 2006;33:290–295.
18. Wittneben JG, Millen C, Brägger U. Clinical performance of screw- versus cement-retained fixed implant-supported reconstructions—A systematic review. Int J Oral Maxillofac Implants 2014;29(suppl):s84–s98.
19. Sotto-Maior BS, Senna PM, da Silva WJ, Rocha EP, Del Bel Cury AA. Influence of crown-to-implant ratio, retention system, restorative material, and occlusal loading on stress concentrations in single short implants. Int J Oral Maxillofac Implants 2012;27:e13–e18.
20. Demenko V, Linetskiy I, Nesvit K, Hubalkova H, Nesvit V, Shevchenko A. Importance of diameter-to-length ratio in selecting dental implants: A methodological finite element study. Comput Methods Biomech Biomed Engin 2014;17:443–449.
21. Lee JH, Frias V, Lee KW, Wright RF. Effect of implant size and shape on implant success rates: A literature review. J Prosthet Dent 2005;94:377–381.
22. Eazhil R, Swaminathan SV, Gunaseelan M, Kannan GV, Alagesan C. Impact of implant diameter and length on stress distribution in osseointegrated implants: A 3D FEA study. J Int Soc Prev Community Dent 2016;6:590–596.
23. Jemt T. Modified single and short-span restorations supported by osseointegrated fixtures in the partially edentulous jaw. J Prosthet Dent 1986;55:243–247.
24. Jemt T, Laney WR, Harris D, et al. Osseointegrated implants for single tooth replacement: A 1-year report from a multicenter prospective study. Int J Oral Maxillofac Implants 1991;6:29–36.
25. Gomez-Roman G, Schulte W, d'Hoedt B, Axman-Krcmar D. The Frialit-2 implant system: Five-year clinical experience in single-tooth and immediately postextraction applications. Int J Oral Maxillofac Implants 1997;12:299–309.
26. Priest G. Single-tooth implants and their role in preserving remaining teeth: A 10-year survival study. Int J Oral Maxillofac Implants 1999;14:181–188.
27. Schincaglia GP, Marzola R, Giovanni GF, Chiara CS, Scotti R. Replacement of mandibular molars with single-unit restorations supported by wide-body implants: Immediate versus delayed loading. A randomized controlled study. Int J Oral Maxillofac Implants 2008;23:474–480.
28. Engquist B, Nilson H, Astrand P. Single-tooth replacement by osseointegrated Brånemark implants. A retrospective study of 82 implants. Clin Oral Implants Res 1995;6:238–245.
29. Annibali S, Bignozzi I, Iacovazzi L, La Monaca G, Cristalli MP. Immediate, early, and late implant placement in first-molar sites: A retrospective case series. Int J Oral Maxillofac Implants 2011;26:1108–1122.
30. Levine RA, Ganeles J, Jaffin RA, Clem DS 3rd, Beagle JR, Keller GW. Multicenter retrospective analysis of wide-neck dental implants for single molar replacement. Int J Oral Maxillofac Implants 2007;22:736–742.