Assessment of Short Dental Implants Restored With Single-Unit Nonsplinted Restorations

Bach T. Le, DDS, MD,* Troy Follmar, DDS,† and Ali Borzabadi-Farahani, DDS, MScD, MOrth RCS (Ed)‡

Objectives: *To investigate the survival rate of short (≤9 mm) implants restored with single-unit, nonsplinted crowns after an average follow-up of 37 months (21–94 months).*

Materials and Methods: *Two hundred and twenty-one implants placed in 168 patients (74 men, 94 women, aged 34–87 years, mean = 61 years). Implant lengths were 6 (n = 16), 8 (n = 166), 8.5 (n = 2), or 9 mm (n = 34). The implant diameters ranged from 3.7 to 5.6 mm. Implants were placed in the maxillary (n = 44) and mandibular arches (n = 176).*

Results: *Survival rate was 94.1% (maxilla [88.6%] and mandible [96.0%]) and 12 early failures (first 4 months) and 1 late failure (4.5 years in the maxillary molar region) observed. Of the 12 early failures, 4 were in the maxilla (2 premolars and 2 molars) and 8 in the mandible (2 premolars and 6 molars). The early failures were 11 implants of 8 mm long and a 9-mm implant. Smoking cigarettes, diabetes mellitus, and bone augmentation procedures were not associated with implant failure significantly (P > 0.05).*

Conclusions: *Survival rate of short implants restored with single-unit, nonsplinted restorations over an average period of 37 months was favorable and comparable with longer implants. (Implant Dent 2013;22:499–502)*

Key Words: short implants, implant survival, implant failures

Although dental implants have been shown to be a beneficial and predictable treatment modality for the long-term restoration of missing teeth,[1] anatomic restrictions can often complicate implant placement. Procedures such as sinus augmentation, guided bone regeneration, distraction osteogenesis, inferior alveolar nerve repositioning, and alveolar osteotomies have been used to address anatomic limitations that would otherwise limit or prevent implant placement. These procedures, however, increase treatment time, carry risks of surgical morbidity, and have varying degrees of success.[2–6] In selected cases, short dental implants (<10 mm in length) have been suggested as an alternative to bone regeneration because of their ability to osseointegrate in a limited volume of residual bone without the need for additional grafting procedures,[7–12] but early studies showed that shorter implants had statistically lower survival rates than longer implants, particularly when placed in the maxillary jaw.[13,14]

However, with modern, rough-surfaced implants, survival rates of short implants are comparable with those of longer ones.[15–20] Furthermore, it has been shown that improvements on existing rough surface technologies can increase implant stability and Implant Stability Quotient values and decrease the marginal bone loss.[21,22] Nonetheless, reports on the success of short dental implants restored with a single unit are limited to 1 implant system (Straumann SLA implants, Basel, Switzerland)[23,24] in the posterior maxillary and mandibular regions[23,24] and only 1 study reported on the survival of 40 short implants over a 2-year period.[23] Moreover, it was not clear whether these studies[23,24] used bone grafting or used nonsplinted restorative protocols.

Therefore, the main objective of this study was to report on the survival of short (≤9 mm) dental implants restored with single-unit, nonsplinted restorations in the maxillary and mandibular regions. The secondary objective was to assess the effect of bone augmentation on the survival of short implants.

Null Hypotheses

This study had 2 null hypotheses. (1) H01: Bone augmentation has no

*Clinical Associate Professor, Department of Oral and Maxillofacial Surgery, The Herman Ostrow School of Dentistry, Los Angeles County/USC Medical Center, University of Southern California, Los Angeles, CA.
†Resident, Department of Oral and Maxillofacial Surgery, The Herman Ostrow School of Dentistry, Los Angeles County/USC Medical Center, University of Southern California, Los Angeles, CA.
‡Clinical Teaching Fellow, Orthodontics, Warwick Dentistry, Warwick Medical School, University of Warwick, Coventry, United Kingdom.

Reprint requests and correspondence to: Bach T. Le, DDS, MD, FICD, FACD, Department of Oral and Maxillofacial Surgery, The Herman Ostrow School of Dentistry, Los Angeles County/USC Medical Center, University of Southern California, Los Angeles, CA, Phone: (323) 361-2130, E-mail: leb97201@yahoo.com

ISSN 1056-6163/13/02205-499
Implant Dentistry
Volume 22 • Number 5

DOI: 10.1097/ID.0b013e31829afaf2

Table 1. Distribution of Short Implants Used in This Study

Implants Used	Straumann	Astra	Zimmer	3i	BioHorizons
N	163	41	14	2	1

effect on the short-term survival of short implants. (2) H02: Implant survival of short implants would be at least 5% higher in mandibles than in maxillae.

MATERIALS AND METHODS

This retrospective study investigated the long-term survival of short dental implants (≤9 mm) placed by a single operator in private practice, between March 2004 and March 2010. The inclusion criteria were patients who had short dental implants (≤9 mm) placed and restored with single-unit, nonsplinted restorations and had follow-up records. Exclusion criteria included patients who had implants with lengths longer than 9 mm placed, restorations that were multiunit or splinted, and/or who failed to follow-up after treatment. Table 1 shows the distribution of implants used in this study. In all cases, implants were placed in a location and orientation such that they would be axially loaded when restored.

Variables recorded included implant success, implant manufacturer, diameter, length, whether periimplant bone augmentation procedures were included in the procedure, and whether each patient had a diagnosis of diabetes mellitus or reported smoking cigarettes. Criteria for implant survival were defined as the ability to support a functional restoration and the absence of pain, mobility, infection, or radiographical lesions (ie, pathologic findings). Conversely, a failed implant was one that exhibited pain, lack of mobility, infection, or the presence of radiological lesions. All failed implants were removed from the patient. Overall, 221 short implants were placed in 168 patients (74 men, 94 women, aged 34–87 years [mean = 61 years]). Implant lengths were 6 (n = 16), 8 (n = 166), 8.5 (n = 2), or 9 mm (n = 34); the implant diameters ranged from 3.7 to 5.6 mm. Implants were placed in the anterior (n = 6) and posterior regions of maxillary (n = 38, 11 premolar and 27 molar regions) and mandibular arches (n = 176, 34 premolar and 142 molar regions). Follow-up ranged from 21 to 94 months (mean = 37 months). All implants placed were restored with single-unit, nonsplinted restorations.

RESULTS

When reviewing records, 13 patients admitted to smoking cigarettes, 18 had diabetes mellitus, and 114 implants had simultaneous bone augmentation procedures (10 sinus lifts and 104 bone augmentation procedures). The χ^2 test did not show a significant association between short implant's survival and variables such as smoking cigarettes, diabetes mellitus, and bone augmentation procedures ($P > 0.05$) (Table 2). Therefore, the first null hypothesis for this study was not rejected. By using descriptive statistics (n, %), 9 Straumann (4.8 × 8 mm, n = 8; 4.1 × 8 mm, n = 1), 2 Astra (4 × 8 mm, n = 1; 5 × 9 mm, n = 1), NS 1 Zimmer (4.7 × 8 mm) failed (n = 13), corresponding to a 94.1% cumulative survival rate. By jaw, implant survival rates were 88.6% (39/44) for maxillary and 96.0% (169/176) for mandibular implants; the second hypothesis was not rejected as well. Time of implant failure was before restoration and/or within the first 4 months of placement (early, n = 12), but there was 1 late failure (4.8 × 8 mm) in a male patient 4.5 years after restoration. This subject had an osteotome sinus lift and a diagnosis of periimplantitis. Of the 12 early failures, 4 were in the maxilla (2 premolars and 2 molars), and 8 were in the mandible (2 premolars and 6 molars).

The early failures were 11 implants of 8 mm long (implant diameters were 4, 4.1, 4.7, and 4.8 mm) and a 5- × 9-mm implant. Of those patients with failure, 1 had diabetes, 4 had onlay grafts, but no one smoked. The only late failure was an implant placed in the maxillary first molar region. Subsequently, 6 of the 12 failed implants were replaced, and all replaced implants were successful.

Table 2. Analysis of the Association Between Diabetes, Augmentation Procedures, Smoking, and the Survival of Short Implants

		Implant Failure			
		No	Yes	Total	χ^2, P
Diabetes	No	192	11	203	0.32
	Yes	16	2	18	—
Augmentation procedures	No	99	8	107	0.40
	Yes	109	5	114	—
Smoking	No	196	12	208	0.77
	Yes	12	1	13	—
Total		208	13	221	—

It seems that none of these variables were significantly associated with the survival of short implants used in this study ($P > 0.05$).

DISCUSSION

Various definitions have been used to describe a short implant. These include an implant length of less than 11 mm,[24,25] 10 mm,[24,26] or 8 mm.[16,24] A more precise definition would be an implant with a designed intrabony length of 8 mm or less.[16,19] For this study, the author's definition of a short implant was one with a length less than or equal to 9 mm. Currently, the minimum required implant length below which implant survival is compromised is not known; however, previous studies reported that implants as short as 6 mm could have a survival rate comparable with longer length implants.[15–24]

As previously noted, the survival rates of short implants in this and other studies may be related, in part, to the use of textured implant surface modification such as moderately rough surfaces (SLActive Starumann), which have been reported to support osseointegration more reliably than machined (turned) surfaces.[22,27–32] Furthermore, the observation that the majority of stresses on a loaded implant is absorbed into the crestal bone at the first few threads, regardless of implant length, may also

be a factor for the survival of short dental implants.[9,18] Pierrisnard et al[33] studied stress analysis around dental implants of the same width (3.75 mm) and different lengths (10, 8, and 6 mm), using finite-element analysis with a 3-dimensional linear elastic model. It was shown that peak stress was located in the first groove of the first thread and that, in areas apical to the first 3 cervical millimeters, the stress intensity was low. This is significant to the current study in that any variation in length of implant in softer cancellous bone has little influence on bone stress.[33] This mirrors the work done by Meijer et al,[34] who studied the stress distribution around implants and showed there was a stress peak in the cervical portion of the implant. Hedia[35] also showed a higher level of stress in cortical bone around the neck of the implant. For achieving equitable stress distribution around short implants, occlusal scheme is an important consideration. Although stress studies have shown that increased implant length has little effect on periimplant bone stress, it has also been shown that lateral forces place much more stress on bone than vertical load and should be avoided, especially when considering the limited bone-implant interface that is achievable with short implants.[36,37] It is, therefore, advisable to place short implants in a location and orientation such that they will be axially loaded when restored,[36–39] which was done in this study. However, the magnitude and the duration of the stress distributed on the implant-supported single crown is relatively small[40]; most short implants are placed in the posterior region with axial loading force on the prosthesis, which is less damaging to the bone-implant surface.[37]

Research on splinting has shown both advantages and potential disadvantages to implant splinting.[40,41] In this study, only nonsplinted implants were selected to eliminate the variable of splinting. The reasons that the restoring clinician did not splint these implants were primarily the lack of an adjacent implant abutment to help support the prosthesis and to facilitate hygiene around the implant by the patient.

This study had several limitations. First, although the present survival/failure criteria had been previously reported[42] in the dental literature, it lacked important information on changes in the crestal bone levels. Second, long-term (≥5 years) outcomes were missing from this study, which only followed up patients for an average of 3 years. Third, the effects of other variables on implant survival, such as differences in implant micro/macro-architecture or surface treatments, were not evaluated. More research is needed to address these unanswered questions.

CONCLUSIONS

This study showed a high success rate of short implants restored with single-unit, nonsplinted restorations. These findings suggest that, in situations where short implants failed, it was most likely to occur during the first 4 months of implant functioning; if the implants did survive 4 months, their survival prognosis for up to 3 years was excellent.

DISCLOSURE

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

REFERENCES

1. Brocard D, Barthet P, Baysse E, et al. A multicenter report on 1,022 consecutively placed ITI implants: A 7-year longitudinal study. *Int J Oral Maxillofac Implants*. 2000;15:691–700.

2. Bormann KH, Suarez-Cunqueiro MM, von See C, et al. Forty sandwich osteotomies in atrophic mandibles: A retrospective study. *J Oral Maxillofac Surg.* 2011;69:1562–1570.

3. Chiapasco M, Romeo E, Casentini P, et al. Alveolar distraction osteogenesis vs. vertical guided bone regeneration for the correction of vertically deficient edentulous ridges: A 1-3-year prospective study on humans. *Clin Oral Implants Res.* 2004;15:82–95.

4. Ferrigno N, Laureti M, Fanali S. Inferior alveolar nerve transposition in conjunction with implant placement. *Int J Oral Maxillofac Implants*. 2005;20:610–620.

5. Robiony M, Zorzan E, Polini F, et al. Osteogenesis distraction and platelet-rich plasma: Combined use in restoration of severe atrophic mandible. Long-term results. *Clin Oral Implants Res.* 2008;19:1202–1210.

6. Rocchietta I, Fontana F, Simion M. Clinical outcomes of vertical bone augmentation to enable dental implant placement: A systematic review. *J Clin Periodontol.* 2008;35(8 suppl):203–215.

7. Fugazzotto PA. Shorter implants in clinical practice: Rationale and treatment results. *Int J Oral Maxillofac Implants*. 2008;23:487–496.

8. Neldam C, Pinholt E. State of the art of short dental implants: A systematic review of the literature. *Clin Implant Dent Relat Res.* 2012;14:622–632.

9. Romeo E, Ghisolfi M, Rozza R, et al. Short (8-mm) dental implants in the rehabilitation of partial and complete edentulism: A 3- to 14-year longitudinal study. *Int J Prosthodont.* 2006;19:586–592.

10. Esposito M, Grusovin MG, Polyzos IP, et al. Interventions for replacing missing teeth: Dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants). *Cochrane Database Syst Rev.* 2010:CD005968.

11. Esposito M, Grusovin MG, Felice P, et al. The efficacy of horizontal and vertical bone augmentation procedures for dental implants—A Cochrane systematic review. *Eur J Oral Implantol.* 2009;2:167–184.

12. Ekfeldt A, Carlsson GE, Börjesson G. Clinical evaluation of single-tooth restorations supported by osseointegrated implants: A retrospective study. *Int J Oral Maxillofac Implants*. 1994;9:179–183.

13. Winkler S, Morris HF, Oshi S. Implant survival to 36 months related to length and diameter. *Ann Periodontol.* 2000;5:22–31.

14. Bahat O. Treatment planning and placement of dental implants in the posterior maxillae: Report on 732 consecutive Nobelpharma implants. *Int J Oral Maxillofac Implants*. 1993;8:151–161.

15. Glantz PO, Nilner K. Biomechanical aspects of prosthetic implant-borne reconstructions. *Periodontol 2000*. 1998;17:119–124.

16. Renouard F, Nisand D. Impact of implant length and diameter on survival rates. *Clin Oral Implants Res.* 2006;17(suppl 2):35–51.

17. 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.

18. Anitua E, Orive G. Short implants in maxilla and mandibles: A retrospective study with 1 to 8 years of follow-up. *J Periodontol.* 2010;81:819–826.

19. Telleman G, Raghoebar GM, Vissink A, et al. A systematic review of the prognosis of short (<10 mm) dental implants placed in the partially edentulous patient. *J Clin Periodontol.* 2011;38:667–676.

20. Monje A, Fu JH, Chan HL, et al. Do implant length and width matter for

short dental implants (6–9 mm)? A meta-analysis of prospective studies. *J Periodontol.* [epub ahead of print] March 1, 2013. doi: 10.1902/jop.2013.120745.

21. Karabuda ZC, Abdel-Haq J, Arisan V. Stability, marginal bone loss and survival of standard and modified sand-blasted, acid-etched implants in bilateral edentulous spaces: A prospective 15-month evaluation. *Clin Oral Implants Res.* 2011;22:840–849.

22. Sul YT, Jönsson J, Yoon GS, et al. Resonance frequency measurements in vivo and related surface properties of magnesium-incorporated, micropatterned and magnesium-incorporated TiUnite, Osseotite, SLA and TiOblast implants. *Clin Oral Implants Res.* 2009;20:1146–1155.

23. Rossi F, Ricci E, Marchetti C, et al. Early loading of single crowns supported by 6-mm-long implants with a moderately rough surface: A prospective 2-year follow-up cohort study. *Clin Oral Implants Res.* 2010;21:937–943.

24. Lai HC, Si MS, Zhuang LF, et al. Long-term outcomes of short dental implants supporting single crowns in posterior region: A clinical retrospective study of 5-10 years. *Clin Oral Implants Res.* 2013; 24:230–237.

25. das Neves FD, Fones D, Bernardes SR, et al. Short implants—An analysis of longitudinal studies. *Int J Oral Maxillofac Implants*. 2006;21:86–93.

26. Morand M, Irinakis T. The challenge of implant therapy in the posterior maxilla: Providing a rationale for the use of short implants. *J Oral Implantol.* 2007;33:257–266.

27. Cochran DL, Nummikoski PV, Higginbottom FL, et al. Evaluation of an endosseous titanium implant with a sandblasted and acid-etched surface in the canine mandible: Radiographic results. *Clin Oral Implants Res.* 1996;7:240–252.

28. Cochran DL, Schenk RK, Lussi A, et al. Bone response to unloaded and loaded titanium implants with a sandblasted and acid-etched surface: A histometric study in the canine mandible. *J Biomed Mater Res.* 1998;40:1–11.

29. Cochran DL, Buser D, ten Bruggenkate CM, et al. The use of reduced healing times on ITI implants with a sandblasted and acid etched (SLA) surface: Early results from clinical trials on ITI SLA implants. *Clin Oral Implants Res.* 2002;12: 144–153.

30. Roccuzzo M, Bunino M, Prioglio F, et al. Early loading of sandblasted and acid etched (SLA) implants: A prospective split-mouth comparative study. *Clin Oral Implants Res.* 2001;12:572–578.

31. Rocuzzo M, Wlison T. A prospective study evaluating a protocol for 6 weeks' loading of SLA implants in the posterior maxilla. *Clin Oral Implants Res.* 2002; 13:502–507.

32. Wennerberg A, Albrektsson T. Effects of titanium surface topography on bone integration: A systematic review. *Clin Oral Implants Res.* 2009;20(suppl 4):172–184.

33. Pierrisnard L, Renauord F, Renault P, et al. Influence of implant length and bicortical anchorage on implant stress distribution. *Clin Implant Dent Relat Res.* 2003;5:254–262.

34. Meijer H, Kuiper J, Starmans F, et al. Stress distribution around dental implants: Influence of superstructure, length of implant, and height of mandible. *J Prosthet Dent.* 1992;68:96–102.

35. Hedia HS. Stress and strain distribution behavior in the bone due to the effect of cancellous bone, dental implant material, and bone height. *Biomed Mater Eng.* 2002;12:111–119.

36. Chang SH, Lin CL, Hsue SS, et al. Biomechanical analysis of the effects of implant diameter and bone quality in short implants placed in the atrophic posterior maxilla. *Med Eng Phys.* 2012;34:153–160.

37. Ding X, Liao SH, Zhu XH, et al. Effect of diameter and length on stress distribution of the alveolar crest around immediate loading implants. *Clin Implant Dent Relat Res.* 2009;11:279–287.

38. Borzabadi-Farahani A. Orthodontic considerations in restorative management of hypodontia patients with endosseous implants. *J Oral Implantol.* 2012;38:779–791.

39. Brunski JB. Biomechanical factors affecting the bone-dental implant interface. *Clin Mater.* 1992;10:153–201.

40. Nissan J, Ghelfan O, Gross M, et al. Analysis of load transfer and stress distribution by splinted and unsplinted implant-supported fixed cemented restorations. *J Oral Rehabil.* 2010;37:658–662.

41. Yang TC, Maeda Y, Gonda T. Biomechanical rationale for short implants in splinted restorations: An in vitro study. *Int J Prosthodont.* 2011;24:130–132.

42. Albrektsson T, Gottlow J, Meirelles L, et al. Survival of NobelDirect implants: An analysis of 550 consecutively placed implants at 18 different clinical centers. *Clin Implant Dent Relat Res.* 2007;9:65–70.