Multicenter Retrospective Analysis of Wide-Neck Dental Implants for Single Molar Replacement

Robert A. Levine, DDS[1]/Jeffrey Ganeles, DMD[2]/Robert A. Jaffin, DMD[3]/Donald S. Clem III, DDS[4]/Jay R. Beagle, DDS, MSD[5]/G. William Keller, DDS[6]

***Purpose**: To evaluate the predictability of Straumann wide-neck dental implants (6.5-mm prosthetic neck with a 4.8-mm endosseous sandblasted, large-grit, acid-etched-surface body) used for molar replacement. **Materials and Methods:** Four hundred ninety-nine single-tooth implants were restored in molar sites in 410 patients (mean time of loading 23 months; range, 1 to 54 months) by 6 clinicians throughout the United States. Three hundred-fifty nine implants were placed in the mandible and 148 implants in the maxilla. **Results:** The overall cumulative survival rate was 98.4% for all sites (8 failures). Survival rates of 99.2% for mandibular molars (3 failures) and 96.6% for maxillary molars (5 failures) were achieved. Survival rate of implants placed in conjunction with the bone-added osteotome procedure in the maxillary molars was 89%, with 5 of 45 procedures leading to failure. **Discussion:** Minimal restorative problems were encountered. No cases of abutment loosening or fractures were observed for cemented restorations on solid abutments. **Conclusion:** The data suggest that the Straumann solid-screw, wide-neck implants can be a satisfactory choice for molar single-tooth replacement.*
INT J ORAL MAXILLOFAC IMPLANTS 2007;22:736–742

Key words: *cemented implant crowns, implant survival, prosthetic complications, wide-diameter dental implants*

Replacement of single missing teeth with implants has followed reports of successful treatment of completely and partially edentulous patients.[1–12] The use of dental implants in posterior sites has proven difficult because of overloading of prosthetic components, inadequate implant diameters, and restorative interfaces not designed for the single-tooth application. A recent report of 675 4.1-mm-body Straumann implants showed a survival rate of 98.4% in restored mandibular molars (n = 370) and 100% in maxillary molars (n = 71) with few prosthetic problems.[9] The purpose of this study was to evaluate the survival of solid-screw, wide-neck endosseous implants for the replacement of single molars with cemented restorations.

MATERIALS AND METHODS

Five-hundred seven solid-screw, wide-neck implants (6.5-mm collar, 4.8-mm diameter body) were placed in 410 patients by 6 periodontists using the standard surgical protocol for Straumann dental implants.[13] All implants were located in the molar region. Two hundred sixty-one implants were placed in mandibular first molar regions, 125 in maxillary first molar regions, 98 in mandibular second molar regions, and 23 in maxillary second molar regions (Figs 1 and 2). Patients included in the study signed a standard informed consent form for implant surgical and restorative procedures. Patients with controlled chronic diseases such as diabetes, cardiovascular disease, or hypertension were not excluded. Cigarette

[1]Clinical Associate Professor in Post-Graduate Periodontics, Perio-Prosthesis and Implantology, University of Pennsylvania School of Dental Medicine; Private Practice in Implantology/Periodontics, Philadelphia, Pennsylvania.
[2]Adjunct Associate Professor, Interim Director Postdoctoral Periodontics, Nova Southeastern University, College of Dental Medicine, Fort Lauderdale, Florida; Private Practice in Implantology/Periodontics, Boca Raton, Florida.
[3]Chief of Periodontal Services, Hackensack University Medical Center; Private Practice in Implantology/Periodontics, Hackensack, New Jersey.
[4]Private Practice in Implantology/Periodontics, Fullerton, California.
[5]Private Practice in Implantology/Periodontics, Indianapolis, Indiana.
[6]Private Practice in Implantology/Periodontics, Wilmington, Delaware.

Correspondence to: Dr Robert A. Levine, Pennsylvania Center for Dental Implants and Periodontics, 9880 Bustleton Avenue, Suite 211, Philadelphia, PA 19115. Email: levineddspc@aol.com

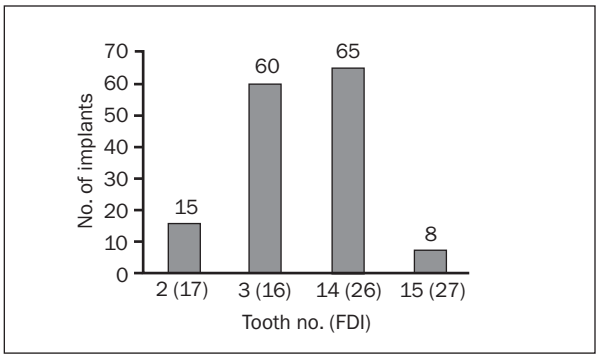


Fig 1 Maxillary molar sites utilized (n = 148).

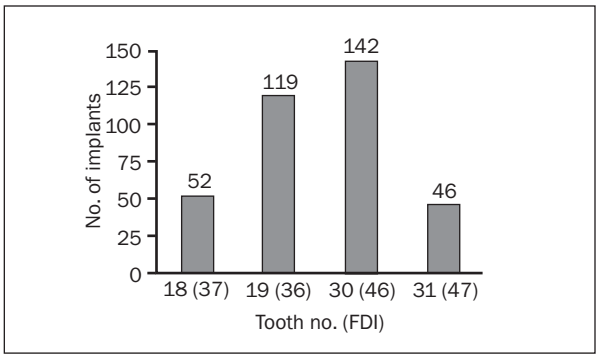
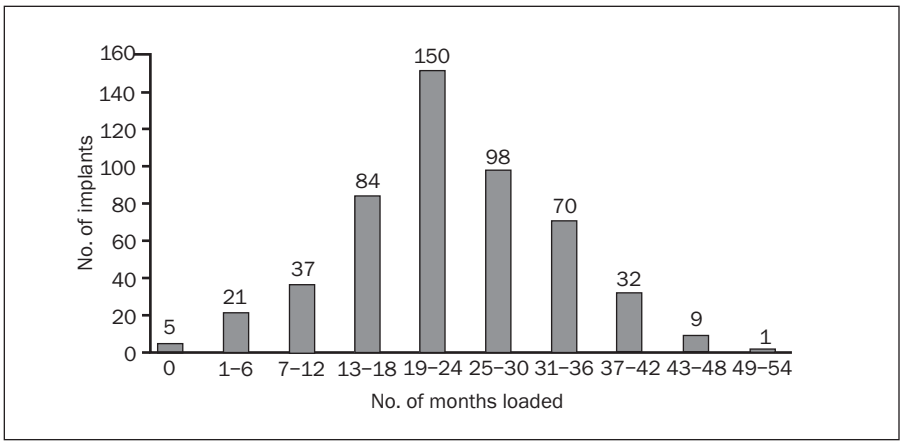


Fig 2 Mandibular molar sites utilized (n = 359).

Fig 3 Distribution of implants by time followed.



smoking and bruxism were not considered exclusion criteria. Implants were placed in extraction sockets and healed sites. Forty-five maxillary implants were placed in conjunction with internal sinus augmentation using a bone-added osteotome (BAO) technique.[14,15] Guided bone regeneration (GBR) was performed on 37 implants to correct osseous defects using resorbable membrane and particulate materials.[16] If primary stability was not achieved, the implant was not placed.

Data collection occurred between September 1998 and December 31, 2002. Follow-up radiographs were obtained for all implants. Implants were examined for integration according to criteria described by Buser et al[17] and were considered successful based upon clinical examination, periapical radiographs, and the absence of symptoms. All implants were restored with solid abutments that were torqued to 35 Ncm after an unloaded healing period of 6 weeks to 6 months. The abutments received cemented restorations. After completion of the prosthetic treatment, all of the patients were placed in a periodontal maintenance program. Complications (surgical and prosthetic) were recorded as they occurred.

RESULTS

Five hundred seven implants were placed in 410 patients, 228 women and 182 men with an age range of 18 to 78 years. Twenty-six patients (6.3%) were smokers. Four hundred ninety-nine wide-neck, single-tooth implants were restored with average time of loading of 23 months (range, 1 to 51 months; Fig 3). Three hundred fifty-nine implants were placed in mandibular molar areas and 148 were placed in maxillary molar sites. The distribution of implants placed and restored by the included clinicians is shown in Fig 4.

The 8-mm-long wide-neck implant was most frequently used (n = 249; 49%), followed by lengths of 10 mm (n = 185; 36%), 12 mm (n = 38; 7.5%), 9 mm (n = 15; 3%), 11 mm (n = 13; 2.5%), 7 mm (n = 3; 0.6%), 13 mm (n = 3; 0.6%), and 14 mm (n = 1; 0.2%; Fig 5).

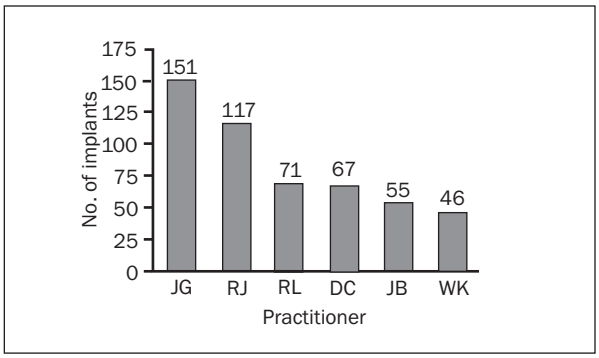


Fig 4 Distribution of implants by practitioner.

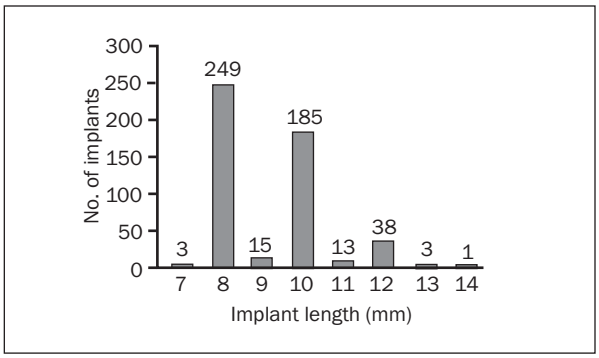


Fig 5 Implant lengths used (n = 507).

Table 1 Analysis of Failures

Site*	Bone type†	Implant length (mm)	Type of restoration	Time to failure	Reason for failure	Implant status
14(26)	4	8		3 wk	BAO, inadequate initial stability, ridge height < 4 mm	Early failure
30(46)	3	8		3 wk	Inadequate initial stability in large socket following immediate placement	Early failure
31(47)	3	8		1 wk	Inadequate initial stability in large socket following immediate placement	Early failure
30(46)	2	10	Single crown	9 mo	Unknown	Late failure
14(26)	4	8		3 wk	BAO, inadequate initial stability, ridge height < 4 mm	Early failure
2(17)	4	8		3 wk	BAO, inadequate initial stability, ridge height < 4 mm	Early failure
3(16)	4	8		3 wk	BAO, inadequate initial stability, ridge height < 4 mm	Early failure
14(26)	4	12		4 mo	BAO, inadequate initial stability, ridge height < 4 mm under a distal extension RPD in a bruxer.	Early failure

*Universal (FDI).
†Lekholm and Zarb.
RPD = removable partial denture.

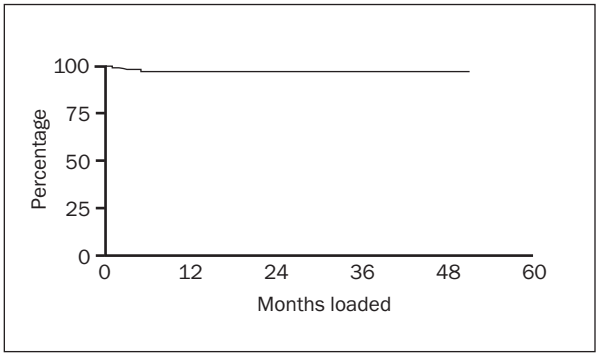


Fig 6 Survival curve (n = 507).

The timing of loading for each patient depended on implant stability and whether GBR (n = 37) or BAO procedures (n = 45) had been performed. Implants placed without augmentation were loaded in 6 to 12 weeks, while those placed with augmentation were loaded in 4 to 6 months.

Eight implants failed to integrate, with 7 failing before prosthetic completion. Of the early failures, 5 were related to unsuccessful BAO procedures in the molar region. The causes of the single late failure were unknown (Table 1).

Survival Rates of Molar Implants by Location

Evaluation of the 148 maxillary molars revealed a survival rate of 96.6% (Fig 6). Of the 45 implants placed with BAO procedures, 5 were early failures. The 359 mandibular molars showed a survival of 99.2%. Three failures were noted (2 early; 1 late).

Restorative Failures and Problems

The 499 functioning implants were restored with cemented restorations on Straumann stock abutments (heights of 4.0 mm or 5.5 mm) which were torqued to the recommended 35 Ncm with a torque wrench from the same manufacturer.

Few sequelae were observed. Cement washout occurred on 2 crowns, 1 case of open contact was

seen, food impaction was evident around 5 crowns (4 mandible, 1 maxilla), and inflammation due to a deep tissue profile impeding cement removal was seen on 1 implant. No abutment loosening or fractures were reported.

Fourteen implants displayed bleeding upon probing, with poor oral hygiene; early visible radiographic bone loss was observed in 1 case.

DISCUSSION

The wide-neck implant introduced by Straumann in 1999 featured an endosseous diameter of 4.8 mm and a 6.5-mm restorative platform to enable a more natural molar emergence profile. Authors have noted that the molar region would be the most logical site for wide-diameter implants.[18–20] Prosthetic treatment with the wide-neck implant is most often accomplished with single implant-borne crowns cemented onto solid abutments. The wide-neck implant prevents excessive mesiodistal contouring of the implant crown and enables a more natural tooth emergence profile than the 4.8-mm prosthetic neck seen in the standard Straumann or wide-bodied implants. These dimensions should also reduce food impaction, a minor complication observed in a previous study.[9]

In the past, wide-diameter implants were used as "rescue implants" for failed standard-diameter implants or in areas of poorer bone quality (types 3 and 4) to increase the surface area available for bone-implant contact.[6,12,18–24] To reduce the risk of implant failure and increase the ability of posterior implants to tolerate occlusal forces, a wide-diameter implant with a broad shoulder was developed. An alternative was to place 2 regular-diameter implants to replace a single molar. This technique doubled the anchorage surface area and reduced rotational forces, which theoretically diminished occlusal screw loosening.[6] Langer et al suggested that the use of a 5-mm-wide implant for this application would make the procedure technically easier and less costly.[21]

There have been few studies on molar replacements with single implants. Bahat and Handelsman recommended the placement of 2 implants to replace a single molar when using an external-hex turned-surface design.[6] A study by Balshi et al[25] compared the use of 1 implant (n = 22 patients) versus 2 implants (n = 25 patients) to replace a single molar (n = 66 mandible; n = 6 maxillae). They reported a significant decrease in screw loosening with 2 implants (8%) as compared to a single implant (48%). However, the single-implant approach increases cost and can be a more challenging procedure for the clinician. Patients often have difficulty performing plaque removal because of the close proximity of the implants to each other or to adjacent teeth. Since the average space for a molar tooth replacement is 9 to 12 mm, this would negate the use of two 4.8-mm-wide regular-neck implants (width at the prosthetic level). The minimum recommended distance between 2 adjacent implants is 3 mm[26]; the minimum recommended distance between implants and teeth is 1.5 mm. The required space to accommodate 2 implants would therefore be a minimum of 16 mm.[27] The use of a single wide-neck implant would satisfy the distances needed between teeth with its 6.5-mm neck. This also simplifies the surgical procedure and in turn reduces potential costs for the patient. Bragger et al[28] assessed and compared economic parameters of treatment options for a single implant versus a 3-unit fixed partial prosthesis and concluded the implant-supported restoration demonstrated a more favorable cost-effectiveness ratio, especially where availability was minimal or nonrestored teeth were adjacent to the space.

Since the molar region is subjected to greater forces of occlusion, it is the ideal location to test survival rates of single-tooth implants. In a study following 134 Straumann titanium plasma-sprayed (TPS) implants placed predominantly in posterior sites, Levine et al[7] reported 3 fractures of hollow-body designs after 2.5 years of loading. The fractures were located in the mandibular molar region. This finding was in agreement with Buser et al[17] and Brocard et al,[29] who found similar hollow-body fractures at similar postloading intervals. Elimination of the hollow-body design in favor of use of solid-bodied implant designs (widths of 4.1 and 4.8 mm) was recommended by the authors. No fractures were reported in a follow-up study by Levine of 674 solid-body 4.1-mm Straumann implants placed in posterior regions.[9] The survival rates for molars in that study were 100% in the maxilla (n = 70) and 98.4% in the mandible (n = 300), which compared favorably with the present wide-neck study (4.8 mm width), with its rates of 96.6% for maxillary molars (n = 148) and 99.2% for mandibular molars (n = 359). These results for standard posteriorly placed implants agree with those of Nedir et al,[11] who reported a survival rate of 99.6%, and Mericske-Stern et al,[8] who reported a 99.1% survival rate.

Becker et al[5] evaluated 282 Nobel Biocare external-hex, turned-surface implants in molar sites for cumulative survival rates (prosthetic problems encountered were not documented). They reported on 70 maxillary molars with a cumulative survival rate of 82.9%. The failure rates were 5% for standard-width implants and 18% for wide-bodied implants. They cited bone quality and quantity[30,31] as well as inability to achieve

bicortical stabilization as reasons for the significant failure rate. Becker reported a cumulative survival rate (CSR) of 91.5% for 212 mandibular molar implants. In a retrospective study, Ivanoff et al[23] reported a relationship between failure and implant diameter, with a higher failure rate for the 5.0-mm-diameter Nobel Biocare external-hex, turned-surface implant. They found a CSR of 73% after 5 years and concluded that the placement of wide implants in dense mandibular bone with low vascularity and remodeling capacity can be a risk. Mordenfeld et al,[32] in a retrospective study of Nobel Biocare external-hex, turned-surface 5-mm wide-platform MKII implants (23 maxillae; 55 mandibles; follow-up of 11 to 58 months), reported a combined CSR of 89.8%, with 95% survival in the mandible and 78% survival in the maxilla. They found a relationship between failure and maxillary placement and also between failure and length of the implant placed. They recommended placement of wide implants longer than 8.5 mm in posterior areas to minimize the risk of failure. Bahat and Handelsman[6] also noted in their study of Nobel Biocare external-hex, turned-surface 5-mm-wide implants and double implants (the use of 2 implants to support a single molar restoration, ie, a 5.0-mm-wide implant with one 3.75 mm or 4.00 mm wide, 2 implants 3.75 mm wide, or 2 implants 4.0 mm wide) that mandibular failure may be attributed to stabilization in only 1 cortical layer in the mandible because of the position of the mandibular nerve in posterior areas.

Eckert et al[20] also reported a significant difference in survival rates with Nobel Biocare wide-platform MKII implants, with a 94% survival rate for standard implants versus 73.8% for wide-bodied implants, with a 71% CSR in the maxillae and a 81% CSR in the mandible and a mean follow-up of 286 days for 85 implants in 63 patients. However, Aparicio and Orozco[33] studied 94 Nobel Biocare self-tapping 5-mm turned-surface implants and reported CSRs of 97.2% in the maxilla and 83.4% in the mandible after 2 years in function. The hypothesized reasons for increased failure with wide-bodied implants include their use in areas of poorer bone quality and quantity (the posterior areas of the mouth), their use in areas with increased occlusal load, impaired primary stability,[32] their association with a longer learning curve,[20] and increased thermal and mechanical trauma to the cortical bone during site preparation.[34] It is also possible that wider implant diameters encroached upon the residual bone volume necessary to achieve and maintain osseointegration.[20]

In a study on posterior single-tooth implants (Straumann 4.1 sandblasted, large-grit, acid-etched [SLA] and TPS), Levine et al[9] observed that half of the implants placed were 10 mm or less. All failures were in the mandibular molar region (4 early, 2 late). Three of 166 8-mm implants placed and 2 of 319 10-mm implants placed were lost. There appeared to be no significant difference in the failure rates for these 2 lengths. The overall mandibular molar survival rate was 98.4% (n = 370), as compared to 100% (n = 70) for maxillary molars. Implant fractures were documented with the hollow-screw and hollow-cylinder designs but not for the solid-body design[7,17,29]; the former 2 designs are no longer available.

In the present study, 89% of the implants were 7 to 10 mm; 49% (n = 249) were 8 mm. The failure rate of 8-mm wide-neck implants (n = 6) was 2.4%; no failures were seen for the 9-mm or 10-mm lengths (n = 15 and n = 185, respectively). These results are in agreement with those of Bischof et al[12]; in their study, the 8-mm wide-neck implants had a survival rate of 97.5% (n = 79) and an overall 2-year survival rate of 97.7% (n = 263, with 255 placed in molar areas).

A recent study by Fugazzotto et al[35] with Straumann rough-surfaced implants confirmed a success rate of 95.1% in maxillary molar sites using 7- to 9-mm 1-stage roughened-surface implants. Krennmair and Waldenberger[18] reported on 121 5.5-mm Frialit-2 implants (74 maxillae; 47 mandibles; 108 TPS step screws and 13 TPS step cylinders). They observed a CSR of 97.3% in the maxilla and a CSR of 100% in the mandible at 12 to 114 months (mean, 41.8 months) for all prosthesis types (eg, single tooth, removable denture prosthesis, prostheses connected with bar or ball attachments). For the 36 implants used in single-tooth applications (1 implant 10 mm long, 18 implants 13 mm long, and 17 implants 15 mm long), they reported a CSR of 100%; they attributed these results to the suitability of the molar area for the wider implant, the achievement of primary stability, and their avoidance of the use of short wide-diameter implants (lengths of 6 to 8 mm). Their recommendation to avoid short implants (implants less than 13 mm long in the molar area) is in disagreement with the present report and other studies.[9,11,12,35] The good survival rates reported with these lengths by other authors may be explained by the use of such implants for planned single-tooth replacement[9,11,12,18] rather than as rescue implants, as reported by others.[19,21] The benefit of increased bone-implant contact in posterior areas, and thus the importance of the use of a roughened-surface implant body over a turned-surface implant body, cannot be overstated.[9,11,12,17,24,30,35]

In the present study, prosthetic complications were minimal with cemented crowns. Minimal prosthetic complications were also observed in a previous study[9] where 98.2% of the restored molars were free of complications. This lack of prosthetic complications sup-

ports the findings of Bischof et al[12]; in their study, 94.3% of the wide-neck implants restored with single crowns were complication-free after 5 years. However, Bragger et al[36] reported greater complication rates at 10 years for 69 Straumann single implants (all hollow screws and cylinders) restored with predominantly cemented single-tooth restorations (67 cemented; 2 screw-retained). Five restorations (7.2%) were lost because of biologic complications, and 2 crowns (2.9%) were remade because of technical complications. Four (5.8%) additional single crowns demonstrated technical complications that did not lead to prosthesis loss or remake. However, the results of that study cannot be compared to those of the present study because of the difference in the implant body designs (solid versus hollow). As noted previously, the hollow-body design has been replaced with the solid-body screw design because of the increased biologic failure rate, including implant fracture, demonstrated with the former design.[8,9,17,36]

In the present study, molar failures were documented as 7 early and 1 late failure with 5 located in the maxillary and 3 in the mandibular arch. Five of the failures in the present study occurred in conjunction with BAO procedures. These failures may be attributed to an aggressive treatment protocol, where BAO procedures were performed on residual ridges less than 5 mm in height.[37,38] BAO survival rates depend on the amount of available bone at placement, as this bone provides initial stability. Thus the potential for increased failure is based on bone available prior to the procedure. Rosen et al[37] reported a survival rate of 96% if more than 4 mm of bone was present but a survival rate of 85.7% if there was less than 4 mm of bone. In the present study, the survival rate for implants placed in conjunction with BAO procedures was 89%. In a recent prospective study by Ferrigno et al[38] of 588 maxillary implants placed in conjunction with osteotome sinus floor elevation and a residual bone height of at least 6 mm, a cumulative survival rate of 94.8% was seen at 12 years. More than 82% of the implants were inserted in 7 to 9 mm of residual bone. The fact that all implants were inserted into adequate bone for initial stabilization of the implant (at least 6 mm), may explain why a greater survival rate was observed with this less aggressive protocol than with that used in the present study. Since graft material does not help support implants placed in BAO procedures, the results of Ferrigno et al[38] and Rosen et al[37] support the use of the osteotome procedure in at least 5 mm of residual bone height to achieve survival and success rates of at least 90%.

In the present study, all early failures showed clinical mobility of the implant. One of these early failures resulted from transmucosal loading under a removable partial denture in conjunction with a bruxing habit. The single late failure occurred in a healthy 79-year-old man 9 months after the placement of a 10-mm implant in a mandibular right first molar site. The cause of this failure was undetermined. Of the 249 8-mm implants placed, only 6 failed, and one 12-mm implant (n = 38) did not integrate. Therefore, length was not a factor in risk assessment of a successful case in the present study. These findings regarding length and implant failure are also in agreement with the recent study of Bischof et al.[12]

CONCLUSIONS

The data suggest that 4.8-mm solid-screw, wide-neck Straumann implants can be an acceptable choice for molar replacement. Few restorative problems were noted for the 499 cemented, loaded implants, and no implant fractures were reported.

The results of the present study indicate that

- The use of 4.8-mm solid-screw, wide-neck SLA implants (6.5 mm prosthetic shoulder) for single molar replacement is a predictable procedure for this patient population.
- Acceptable survival rates can be achieved with this procedure. The CSR for 507 wide-neck implants was 98.4%, with 8 failures documented based on the criteria for success proposed by Buser et al.[17] The CSR for individual molar sites was 99.2% for mandibular molars and 96.6% for maxillary molars. After loading, the survival rate was 99.5%.
- Replacement of a single molar with a restoration supported by 2 implants is not recommended.

REFERENCES

1. Laney WR, Jemt T, Harris D, et al. Osseointegrated implants for single-tooth replacement: Progress report from a multicenter prospective study after 3 years. Int J Oral Maxillofac Implants 1994;9:49–54.
2. 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.
3. Engquist B, Nilson H, Ostrand P. Single-tooth replacement with osseointegrated Brånemark implants: A retrospective study of 82 implants. Clin Oral Implants Res 1995;6:238–245.
4. Levine RA, Clem DS III, Wilson TF Jr, Higginbottom F, Saunders SL. A multi-center retrospective analysis of the ITI implant system used for single-tooth replacements: Preliminary results at 6 or more months of loading. Int J Oral Maxillofac Implants 1997;12:237–242.
5. Becker N, Becker BE, Alsuwyed A, Al-Mubarak S. Long-term evaluation of 282 implants in maxillary and mandibular molar positions: A prospective study. J Periodontol 1999;70:896–901.

6. Bahat O, Handelsman M. Use of wide implants and double implants in the posterior jaw: A clinical report. Int J Oral Maxillofac Implants 1996;11:379–386.
7. Levine RA, Clem DS III, Wilson TG Jr, Higginbottom F, Solnit G. Multicenter retrospective analysis of the ITI implant system used for single-tooth replacements. Results of loading for 2 or more years. Int J Oral Maxillofac Implants 1999;14:516–520.
8. Mericske-Stern R, Grutter L, Rosch R, Mericske E. Clinical evaluation and prosthetic complications of single tooth replacements by non-submerged implants. Clin Oral Implants Res 2001;12:309–318.
9. Levine RA, Clem D, Beagle J, et al. Multicenter retrospective analysis of the solid-screw ITI implant for posterior single-tooth replacements. Int J Oral Maxillofac Implants 2002;17:550–556.
10. Levin L, Laviv A, Schwartz-Arad D. Long-term success of implants replacing a single molar. J Periodontol 2006;77: 1528–1532.
11. Nedir R, Bischof M, Briaux JM, Beyer S, Szmukler-Moncler S, Bernard JP. A 7-year life table analysis from a prospective study on ITI implants with special emphasis on the use of short implants. Results from a private practice. Clin Oral Implants Res 2004;15:150–157.
12. Bischof M, Nedir R, Abinajm S, Szmukler-Moncler S, Samson J. A 5-year life-table analysis on wide neck ITI implants with prosthetic evaluation and radiographic analysis: Results from a private practice. Clin Oral Implants Res 2006;17:1–9.
13. Buser D, von Arx T, ten Bruggenkate C, Weingart D. Basic surgical principles with ITI implants. Clin Oral Implants Res 2000; 11(suppl):59–68.
14. Summers RB. The osteotome technique: Part 3—Less invasive methods of elevating the sinus floor. Compendium 1994;15: 698–708.
15. Darvarpanah M, Martinez H, Tecucianu JF, Hage G, Lazzara R. The modified osteotome technique. Int J Periodontics Restorative Dent 2001;21:599–607.
16. Hammerle CH, Jung RE. Bone augmentation by means of barrier membranes. Periodontol 2000 2003;33:36–53.
17. Buser D, Mericske-Stern R, Bernard JP, et al. Long-term evaluation of nonsubmerged ITI implants. Clin Oral Implants Res 1997;8:161–172.
18. Krennmair G, Waldenberger O. Clinical analysis of wide-diameter Frialit-2 Implants. Int J Oral Maxillofac Implants 2004;19: 710–715.
19. Handelsman M. Treatment planning and surgical considerations for placement of wide-body implants. Compend Contin Educ Dent 1998;19:507–514.
20. Eckert SE, Meraw SJ, Weaver AL, Lohse CM. Early experience with wide-platform MKII implants. Part I: Implant survival. Part II: Evaluation of risk factors involving implant survival. Int J Oral Maxillofac Implants 2001;16:208–216.
21. Langer B, Langer L, Herrman I, Jorneus L. The wide fixture: A solution for special bone situations and a rescue for the compromised implant. Part 1. Int J Oral Maxillofac Implants 1993;8: 400–408.
22. English C, Bahat O, Langer B, Sheets CG. What are the clinical limitations of wide-diameter (4 mm or greater) root-form endosseous implants? Int J Oral Maxillofac Implants 2000; 15:293–296.
23. Ivanoff CJ, Grondahl K, Sennerby L, Bergstrom C, Lekholm U. Influence of variations in implant diameters: A 3- to 5-year retrospective clinical report. Int J Oral Maxillofac Implants 1999; 14:173–180.
24. Bischof M, Pinho de Oliveira R, Nedir R, Briaux J-M, Bernard JP. ITI wide neck implants: A 4-year life-table analysis from a multi-center study with 186 implants [abstract]. Clin Oral Implants Res 2002;13:xxiii.
25. Balshi TJ, Hernanden 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.
26. Tarnow DP, Cho SC, Wallace SS. The effect of inter-implant distance on the height of inter-implant bone crest. J Periodontol 2000;71:546–549.
27. Buser DB, Martin W, Belser UC. Optimizing esthetics for implant restorations in the anterior maxilla: Anatomic and surgical considerations. Int J Oral Maxillofac Implants 2004(suppl);19:43–61.
28. Bragger U, Krenander P, Lang NP. Economic aspects of single-tooth replacement. Clin Oral Implants Res 2005;16:335–341.
29. Brocard D, Barthet P, Baysse E, et al. A multicenter report on 1,222 consecutively placed ITI implants: A 7-year longitudinal study. Int J Oral Maxillofac Implants 2000;15:691–700.
30. Jaffin RA, Berman CL. The excessive loss of Brånemark fixtures in type IV bone: A 5-year analysis. J Periodontol 1991;62:2–4.
31. Buser D, Nydegger T, Hirt HP, Cochran DL, Nolte LP. Removal torque values of titanium implants in the maxilla of miniature pigs. Int J Oral Maxillofac Implants 1998;13:611–619.
32. Mordenfeld MH, Johansson A, Hedin M, Bellstrom C, Fyrberg KA. A retrospective clinical study of wide-diameter implants used in posterior edentulous areas. Int J Oral Maxillofac Implants 2004;19:387–392.
33. Aparicio C, Orozco P. Use of 5-mm diameter implants: Periotest values related to a clinical and radiographic evaluation. Clin Oral Implants Res 1998;9:398–406.
34. Renouard F, Arnoux JP, Sarment DP. Five-mm-diameter implants without a smooth surface collar: A report on 98 consecutive placements. Int J Oral Maxillofac Implants 1999;14: 101–107.
35. Fugazzotto PA, Beagle JR, Ganeles J, Jaffin R, Vlassis J, Kumar A. Success and failure rates of 9 mm or shorter ITI implants in the replacement of missing molars when restored with individual crowns. Preliminary result 0 to 84 months in function: A retrospective study. J Periodontol 2004;75:327–332.
36. Bragger U, Karoussis I, Persson R, Pjetursson B, Salvi G, Lang NP. Technical and biological complications/failures with single crowns and fixed partial dentures on implants: A 10-year prospective cohort study. Clin Oral Implants Res 2005;16: 326–334.
37. Rosen PS, Summers R, Mellado JR, et al. The bone-added osteotome (BAO) sinus floor elevation technique: Multicenter retrospective report of consecutively treated patients. Int J Oral Maxillofac Implants 1999;14:853–858.
38. Ferrigno N, Laureti M, Fanali S. Dental implant placement in conjunction with osteotome sinus floor elevation: A 12-year life-table analysis from a prospective study on 588 ITI implants. Clin Oral Implants Res 2006;17:194–205 [erratum 2006;17:479].