Multicenter Retrospective Analysis of the Solid-Screw ITI Implant for Posterior Single-Tooth Replacements

Robert A. Levine, DDS[1]/Donald Clem, DDS[2]/Jay Beagle, DDS[3]/Jeffrey Ganeles, DDS[4]/
Peter Johnson, DDS[5]/Gary Solnit, DDS, MS[6]/G. William Keller, DDS[7]

Purpose: *This report involves the retrospective analysis of ITI implants placed and/or restored by a group of 7 clinicians located throughout the United States (5 periodontists and 2 prosthodontists).* ***Materials and Methods:*** *Six hundred seventy-five posterior single-tooth implants were restored in 471 patients (average time of loading 21.30 months, with a range of 1 to 78 months). Three hundred seventy implants and 71 implants were placed in mandibular and maxillary molar sites, respectively, and 108 and 126 were placed in mandibular and maxillary premolar sites, respectively.* ***Results:*** *A cumulative survival rate of 99.1% was obtained for all sites (6 failures). The survival rates for individual sites were as follows: 98.4% mandibular molars, 100% maxillary molars, 100% mandibular premolars, and 100% maxillary premolars. "At-risk" implants (1 to 2 mm of radiographic bone loss) were noted at 5 sites.* ***Discussion:*** *Minimal restorative problems were found with either screw-retained (n = 71) or cemented restorations on solid abutments (n = 600); 80.3% of screw-retained and 98.2% of cemented restorations were free of complications, respectively. Patient satisfaction scores were high (97.4%) as determined by the Patient Satisfaction Questionnaire.* ***Conclusion:*** *The data suggest that solid-screw (4.1 or 4.8 mm wide) ITI implants can be a satisfactory choice for posterior single-tooth restorations.*
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Key words: *dental prosthesis retention, implant crown, single-tooth dental implant, survival rate*

Osseointegrated dental implants have become the standard of care for treatment planning patients who are either completely or partially edentulous, as well as patients who are missing single teeth. Evidence-based studies have confirmed that dental implants have an excellent long-term favorable prognosis when compared to conventional fixed partial dentures.[1–4] The benefits of implants over conventional fixed prostheses include caries resistance and the avoidance of removal of tooth structure of adjacent teeth via tooth preparation. The ability to replace single missing teeth with single implants should be the goal if in fact the clinician's objective is to replace what has been lost. This service enables patients to enjoy the benefits of comfortable function, pleasing esthetics, freedom from marginal caries and concerns involving restorations, and optimal oral hygiene access.[5–7]

A limitation of early single-tooth implant studies was the lack of molar restorations in the investigated populations.[8–10] The molar region could be the ideal area in a patient's mouth for testing the success of single implants, since a lone-standing implant would be most severely tested under many types of occlusal, masticatory, and parafunctional loads. Becker and coworkers[11] reported on 282 implants

[1]Chairman, Department of Periodontics, Albert Einstein Medical Center, Philadelphia, Pennsylvania; Private Practice in Periodontics and Implantology, Philadelphia, Pennsylvania.
[2]Private Practice in Periodontics/Implantology, Fullerton, California.
[3]Private Practice in Periodontics/Implantology, Indianapolis, Indiana.
[4]Clinical Assistant Professor, Department of Periodontology, Nova Southeastern University, College of Dental Medicine, Fort Lauderdale, Florida; Private Practice in Periodontics/Implantology, Boca Raton, Florida.
[5]Associate Clinical Professor, University of Southern California School of Dentistry, Los Angeles, California; Private Practice in Prosthodontics/Implantology, San Diego, California.
[6]Private Practice in Prosthodontics/Implantology, Beverly Hills, California.
[7]Private Practice in Periodontics/Implantology, Wilmington, Delaware.

Reprint requests: Dr Robert Levine, 9880 Bustleton Ave, Suite 211, Philadelphia, PA 19115. Fax: +215-677-7212.

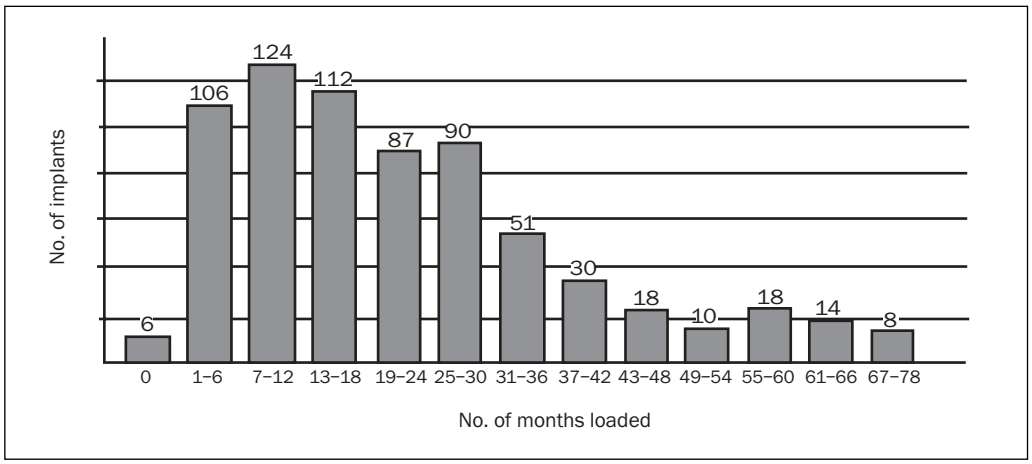
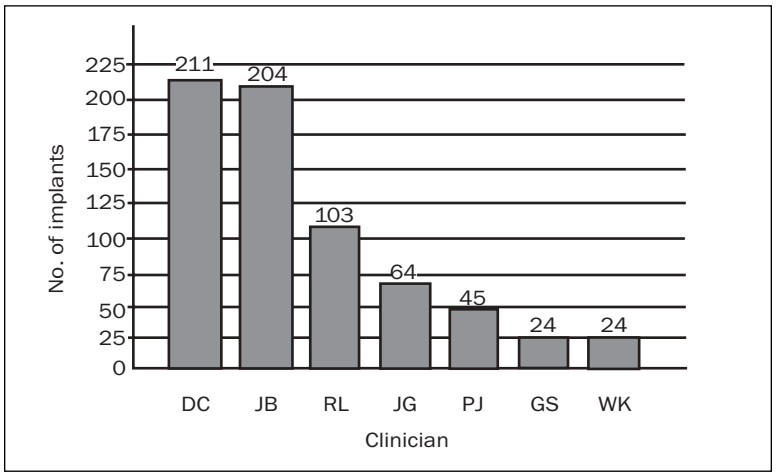


Fig 1 Loading time, in months, of 675 solid-screw ITI implants placed in the posterior maxilla or mandible as single-tooth replacements.

Fig 2 Study participants of solid-screw posterior ITI implant study. Chart shows number of cases either surgically placed (periodontist) or restored (restorative dentist) by the participating clinicians.



placed in molar positions and found striking differences in cumulative success in the mandibular molar versus the maxillary molar regions (91.5% versus 82.9%, respectively). They attributed this outcome to differences in bone quality and quantity in posterior areas as compared to anterior regions, where success profiles have been reported to be significantly better. Levine and associates[12] reported a 95.5% cumulative success rate for 157 implants, with 135 of them being placed posteriorly (75 in the molar and 16 in the premolar region). The survival rate of the molar population was 92%, whereas the survival rate of the premolar population was 99.98%. Three fractures of hollow-body implants were reported in the mandibular first molar area (12% fracture rate in molar region). This was found to be a result of the implant design being overused in this area of the mouth, where the load is too great for the specific hollow-body design.

The purpose of the present study was to evaluate the survival of 675 solid-screw ITI implants for the replacement of single posterior teeth. In addition, the survival of cemented versus screw-retained single-implant–supported crowns was compared.

MATERIALS AND METHODS

Six hundred seventy-five solid-screw ITI implants (Straumann, Waldenburg, Switzerland) were placed in 471 patients (292 women, 179 men). The data were collected from 7 clinical practices throughout the United States (5 periodontists and 2 prosthodontists). Although there was no definite commencement date, the data collection period ended August 1, 1999. Implant selection was based on consecutive placement and followed from the day of surgery to at least 1 month post-restoration. Consecutive periapical radiographs were necessary for inclusion in the study (Fig 1; median 18 months). The distribution of implants placed and/or restored by the included clinicians was as follows (Fig 2):

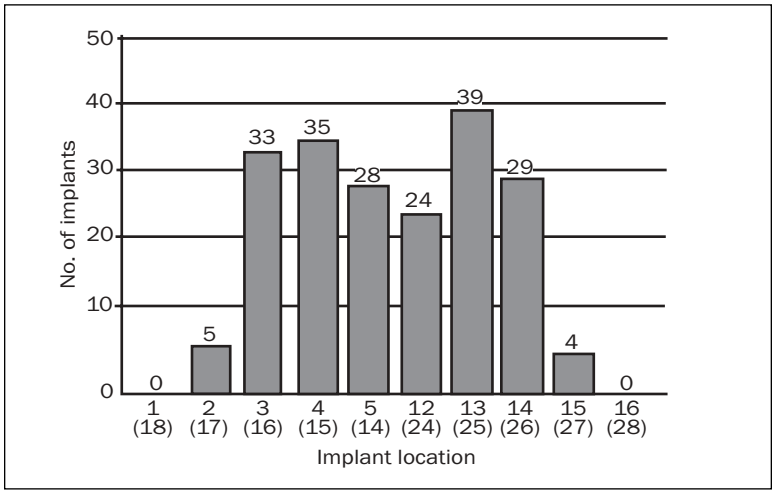


Fig 3 Maxillary posterior sites utilized, n = 197 implants placed. Tooth numbers are Universal (FDI in parentheses).

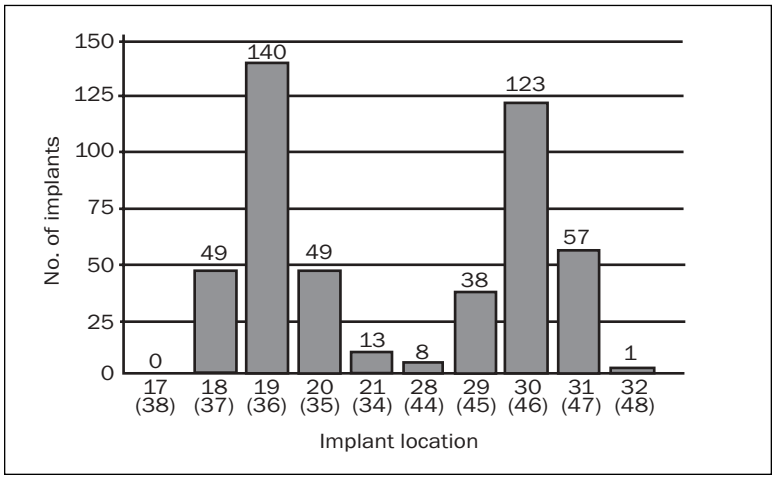


Fig 4 Mandibular posterior sites utilized, n = 478 implants placed. Tooth numbers are Universal (FDI in parentheses).

- Clinician 1, 211
- Clinician 2, 204
- Clinician 3, 103
- Clinician 4, 64
- Clinician 5, 45
- Clinician 6, 24
- Clinician 7, 24

The patients were considered healthy by their clinicians (only 12.6% of the implants were placed in smokers).

All implants were located in the posterior region of the mouth and delineated as follows: mandibular molar (370), maxillary premolar (126), mandibular premolar (108), and maxillary molar (71) (Figs 3 and 4). Of the implants placed, 615 were 4.1 mm wide (standard width) and 60 were 4.8 mm wide (wide-body). The 10-mm-long implants were the most frequently used (319), followed by the 8-mm (166), 12-mm (131), 14-mm (24), 11-mm (21), 9-mm (9), and 16-mm (5) (Fig 5). Six hundred one implants were titanium plasma-spray (TPS) coated, while 74 were sandblasted/acid-etched (SLA). The implants were examined for successful tissue integration according to success criteria described by Buser and coworkers,[3] with each implant being classified as "early failure" because of recurrent peri-implant infection or implant mobility or "successful" based on the criteria (Fig 6), which depended upon clinical and periapical radiographic examinations of each site. Of the successfully integrated implants, 600 were restored with solid abutments and cemented restorations, and 71 were restored with the octabutment and screw-retained restorations.

After completion of the prosthetic treatment, the majority of patients were placed in a periodontal maintenance program with visits every 3 to 6 months. Complications were recorded as they occurred and included loosening or fracture of solid abutments for cemented crowns, loosening or fracture of crown-retaining screws, loosening of octabutments for

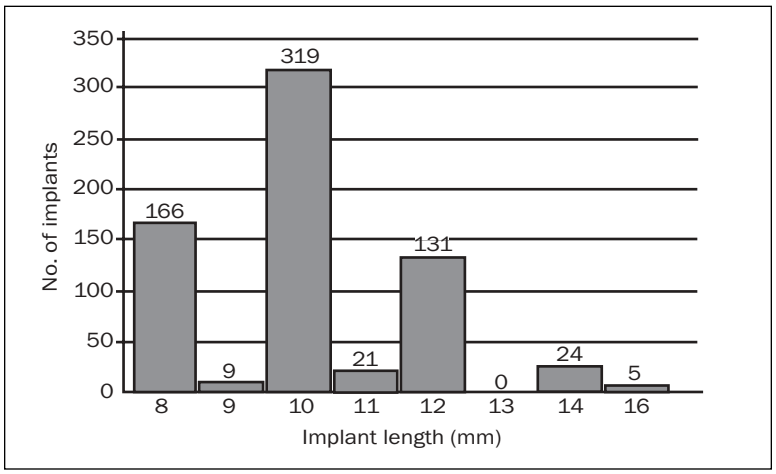


Fig 5 Implant lengths used in the study; 71.85% were 8 to 10 mm long.

Criteria for success

1. Absence of persistent subjective complaints such as pain, foreign body sensation, and/or dysesthesia
2. Absence of recurrent peri-implant infection with suppuration
3. Absence of mobility
4. Absence of continuous radiolucency around the implant

Fig 6 Criteria for success from Buser and associates 1997.[3]

screw-retained restorations, marginal bone loss, implant failure, and implant fracture.

Each patient was given a Patient Satisfaction Questionnaire when treatment was completed. The questionnaire was filled out by the patient, with any additional comments also noted by the patient. The scale ranged from 1 (very unhappy) to 3 (neutral) to 5 (very happy), according to how they felt about the results of their treatment.

RESULTS

Evaluation of the treatment during the healing period of 6 to 8 weeks (for SLA surface only) to 4 months (for TPS surface implants placed in Type 4 bone quality) revealed 4 implants that failed to integrate. In addition, 2 implants demonstrated peri-implant infection, with significant bone loss and poor prognosis, and were considered "late failures." Five implants had pocketing (5 to 7 mm) and minimal (1 to 2 mm as measured radiographically) marginal bone loss and were considered "at risk" but were stable, non-mobile, symptom-free, and in function.

Survival Rates of Posterior Implants by Location

This analysis showed differences among all categories as follows: the mandibular molar survival rate (n = 370) was 98.4% as compared to 100% for maxillary molars (n = 71). In the premolar region 100% survival was noted for both the mandible (n = 108) and the maxilla (n = 126). The overall survival rate was 99.1%. No implant fractures were noted for either diameter used.

Restorative Failure and Problems

Of the 671 implant restorations, 600 were restored as cemented crowns on solid abutments and 71 were restored as screw-retained crowns on octabutments.

Problems with the cemented restorations were as follows. In 2 patients, abutment loosening was seen (0.3%); in 3 patients, solid abutments fractured and needed to be replaced and new crowns fabricated (0.5%); 4 crowns loosened because of cement washout and were re-cemented (0.6%); and 2 additional crowns were remade because of porcelain fracture in 1 patient and poor seating and laboratory error in another (both 0.2% occurrence).

Problems associated with screw-retained restorations were as follows. In 12 patients (16.9%) the crown-retaining screw loosened once, in 1 patient (1.4%) the crown-retaining screw loosened multiple times, and in 1 patient (1.4%) the octabutment loosened once. In all patients, either the crown-retaining screw was retorqued at 20 Ncm, or the 1

octabutment was retorqued to 35 Ncm and the overlying crown retorqued to 20 Ncm. The ITI System torque wrench was used in each instance of retorqueing.

Patient Satisfaction Questionnaire

A total of 454 responses (1 response per each implant restored) were received by the primary author from a total of 671 with completed treatment, for a total 67.7% response rate; 97.4% of the responders were either happy or very happy with their restoration (n = 442), while 2.6% were unhappy or neutral (n = 12). The primary author was able to have all patients respond to the satisfaction questionnaire at a subsequent visit and found 100% of the patients responding either happy or very happy with their results. However, 16 responses indicated "food impaction between teeth," especially in the mandibular molar area when a single implant replaced a molar tooth.

Introduction of the wide-neck (WN) implant by Straumann, which features a 4.8-mm solid-screw, bone-anchored section and a prosthetic shoulder diameter of 6.5 mm, is a significant improvement for the replacement of single missing molars. The WN implant can now be used to avoid excessive mesiodistal overcontouring of the implant superstructure or extremely open interproximal embrasures, which may lead to food impaction and/or oral parafunctional habits.[13] The present authors are now studying the survival rate of the wide-neck implant in molar sites ≤ 12 mm mesiodistally. Initial data confirm that this implant can be an ideal choice for most molar replacements where adequate bone quantity is present. The improvement in emergence profile has virtually eliminated complaints of food impaction, which were seen with the use of a standard ITI implant in a similar molar application.

DISCUSSION

The literature has been devoid of meaningful studies on the use of dental implants in the posterior regions of the mouth. The present authors have concentrated on this area; it is believed that the most important area in the mouth to evaluate implant success and strength is the posterior region, since occlusal and parafunctional loads are most concentrated in this region. A recent study[12] followed (mean 40.1 months) 135 posteriorly placed implants in which the cumulative survival rate (CSR) of the molar population was 92%, whereas the CSR of the premolar population was 99.98%. Implant fracture was noted in this previous study, and analysis found that all were in the mandibular first molar area (total of 3 fractures) and all were hollow (3.5-mm-wide) implant bodies. The implant fractures had occurred after a mean service period of 40.3 months. None of the solid-screw (4.1-mm-diameter) implants fractured. It appears that the hollow-body implant does not always have adequate strength to withstand posterior forces of occlusion as a single-tooth replacement, whereas the 4.1-mm solid screw does have the needed strength for posterior application. The authors decided to test the 4.1- and the 4.8-mm wide-body solid-screw implants in posterior areas to evaluate their CSR and prosthetic strengths and weaknesses in single-tooth applications.

A recent study by Becker and associates[11] evaluated 282 implants in molar positions for CSR only. No mention was made of any prosthetic problems as in the present and prior studies. The comparison that can be made with the Becker study would be only in the molar region. The Becker study reported on 70 while the present group reported on 71 maxillary molar implants. The CSR was 100% in the present study for maxillary molars, whereas the Becker study reported a CSR of 82.9%. The 370 mandibular molars followed in the present study and the 212 in the Becker study showed CSRs of 98.4% and 91.5%, respectively. Becker and associates cited bone quality and quantity and variability in achieving bicortical stabilization as reasons for lower success rates in molar positions when compared with the anterior region of the mouth. Machined-surface titanium implants, ad modum Brånemark, have extremely high success rates in the anterior and the intraforaminal region of the mandible because of bicortical stabilization in these regions. However, in posterior areas[14] there is less bone surface available for implant contact, which may account for the differences in CSR between this material and Becker's. This effect has been documented in animal studies.[15,16]

One interesting finding in a previous study[7] was that a majority of the implants placed in posterior areas were of relatively short lengths, ie, 8 to 10 mm. TPS and SLA surfaces usually do not require bicortical stabilization. The present study seems to confirm this as well as the ability of these surfaces to be successful in significantly reduced ridges with the use of shorter implants, ie, 8 mm, 9 mm, or 10 mm. All failures in the present study were located in the mandibular molar region. Failure rates by implant length were as follows: 3 of 166 (1.8%) for 8-mm implants and 2 of 319 (0.6%) for 10-mm implants. There appears to be a slight increase in failure rates for the 8-mm to 10-mm length; however, survival rates of 98.2% versus 99.4% are both clinically satisfactory.

The strength of the 4.1- and 4.8-mm ITI solid-screw implants was documented in the present study with a mean loading time of over 21 months. However, in previous studies,[3,12] implant fractures were initially seen at 2 1/2 years with hollow-body implants. Thus, the present data may be too short-term to realize any fractures. To date, no fractures of either 4.1- or 4.8-mm ITI solid-screw implants have been reported.[17]

Another finding from the present study was the number of restored cases with multiple contiguous units. The mandible had 68 cases of 2 single restored units and 21 cases of 3 single restored contiguous units, while the maxilla had a total of 19 cases with 2 or 3 contiguous units. Not only were they successful, with only 1 failure (an 8-mm implant in a mandibular first molar region), there may be a "protective" effect of multiple contiguous implants: it enables patients to be restored as if they had received their original adult dentition with access to floss interproximally. The standard and wide-diameter TPS and SLA titanium solid-screw implants appear to be satisfactory replacements for either single or multiple missing posterior teeth, even when subjected to the heavy occlusal forces that are seen in the molar areas.[12,17] The need for "tripodization,"[18,19] which has been recommended for 2-stage external-hex implant systems, is not a requirement for these implants and appears to be confirmed again by these data.

In the present study, the more user-friendly restoration based on minimal prosthetic complications was the cemented restoration on a solid abutment versus the screw-retained restoration with the octabutment. A recent study of machined-surface titanium implants compared in vitro 3 different implant-prosthesis connection systems (1 cemented, 2 screw-retained) with respect to their capability to compensate fixed prosthesis dimensional and/or shape errors.[20] The authors found that the cemented abutments had the best capability of compensating translation (axial and transversal) errors via significant strain reduction. They proposed that a possible explanation for their findings could be the presence of a deformable cement layer, which might compensate the translation errors produced during the manufacturing process.[20] It was theorized that the cement could thus act as an absorber for the deformation caused by the manufacturing mismatch and may be capable of preserving the implant-abutment-prosthesis stack from greater strains. Although the present cases involve in vivo treatment, the results of this in vitro study may be a valid explanation for the lack of problems with cemented single crowns seen in the present population.

CONCLUSIONS

The results of the present study have indicated that the use of TPS-coated and SLA solid-screw implants for posterior single-tooth replacement can be a predictable procedure. The cumulative survival rate of 675 implants placed was 99.1%, with only 6 failures recorded. Based on the criteria for success by Buser and associates,[3] the CSR for individual sites was 98.4% for mandibular molars and 100% for maxillary molars and premolars as well as mandibular premolars. One to 2 mm of bone loss was recorded radiographically on an additional 5 implant sites, and these were noted as "at-risk" sites. Minimal restorative problems were recorded, as 80.3% of screw-retained and 98.2% of cemented restorations were complication-free. No implant fractures were noted with the use of either the standard 4.1-mm-diameter or the 4.8-mm wide-body implants.

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REFERENCES

1. Buser D, Weber HP, Lang NP. Tissue integration of non-submerged implants. 1-year results of a prospective study with 100 ITI hollow-cylinder and hollow-screw implants. Clin Oral Implants Res 1990;1:33–40.
2. Buser D, Weber H-P, Brägger U, Balsiger C. Tissue integration of one-stage ITI implants: 3-year results of a longitudinal study with hollow-cylinder and hollow-screw implants. Int J Oral Maxillofac Implants 1991;6:405–412.
3. Buser D, Mericske-Stern R, Bernard JP, et al. Long-term evaluation of nonsubmerged ITI implants. Clin Oral Implants Res 1997;8:161–172.
4. Cochran DL. The scientific basis for and clinical experiences with Straumann implants including the ITI Dental Implant System: A consensus report. Clin Oral Implants Res 2000;11(suppl):33–58.
5. Belser UC, Mericske-Stern R, Bernard JP, Taylor TD. Prosthetic management of the partially dentate patient with fixed implant restorations. Clin Oral Implants Res 2000;11(suppl): 126–145.
6. Levine RA, Wilson TG, Weber HP. The ITI Dental Implant System. Compend Contin Educ Dent 1994;XV:526–535.
7. Levine RA, Clem DS III, Wilson TF Jr, Higginbottom F, Saunders SL. A multicenter 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.
8. 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.

9. 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.
10. Engquist B, Nilson H, Ostrand P. Single-tooth replacement with osseointegrated Brånemark implants. Clin Oral Implants Res 1995;6:238–245.
11. 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.
12. 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.
13. Belser VC, Mericske-Stern R, Bernard JP, Taylor TD. Prosthetic management of the partially dentate patient with fixed restorations. Clin Oral Implants Res 2000;11(suppl):126–145.
14. Jaffin RA, Berman CL. The excessive loss of Brånemark fixtures in type IV bone: A 5-year analysis. J Periodontol 1991; 62:2–4.
15. 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.
16. Carlson L, Rostlund T, Albrektsson B, Albrektsson T. Removal torques for polished and rough titanium implants. Int J Oral Maxillofac Implants 1988;3:21–24.
17. Schwartz MS. Mechanical complications of dental implants. Clin Oral Implants Res 2000;11(suppl):156–158.
18. Rangert B, Sullivan R. Biomechanical principles preventing prosthetic overload induced by bending. Nobelpharma News 1993;7:4–5.
19. Rangert BR, Sullivan RM, Jemt TM. Load factor control for implants in the positive partially edentulous segment. Int J Oral Maxillofac Implants 1997;12:360–370.
20. Pietrabissam R, Gionso L, Quaglini V, DiMartino E, Simion M. An in vitro study on compensation of mismatch of screw versus cement-retained implant supported fixed prostheses. Clin Oral Implants Res 2000:11:448–457.