

# Long-Term Outcome of Cemented Versus Screw-Retained Implant-Supported Partial Restorations

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**Purpose:** The present study was designed to compare the long-term outcome and complications of cemented versus screw-retained implant restorations in partially edentulous patients. **Materials and Methods:** Consecutive patients with bilateral partial posterior edentulism comprised the study group. Implants were placed, and cemented or screw-retained restorations were randomly assigned to the patients in a split-mouth design. Follow-up (up to 15 years) examinations were performed every 6 months in the first year and every 12 months in subsequent years. The following parameters were evaluated and recorded at each recall appointment: ceramic fracture, abutment screw loosening, metal frame fracture, Gingival Index, and marginal bone loss. **Results:** Thirty-eight patients were treated with 221 implants to support partial prostheses. No implants during the follow-up period (mean follow-up,  $66 \pm 47$  months for screw-retained restorations [range, 18 to 180 months] and  $61 \pm 40$  months for cemented restorations [range, 18 to 159 months]). Ceramic fracture occurred significantly more frequently ( $P < .001$ ) in screw-retained ( $38\% \pm 0.3\%$ ) than in cemented ( $4\% \pm 0.1\%$ ) restorations. Abutment screw loosening occurred statistically significantly more often ( $P = .001$ ) in screw-retained ( $32\% \pm 0.3\%$ ) than in cement-retained ( $9\% \pm 0.2\%$ ) restorations. There were no metal frame fractures in either type of restoration. The mean Gingival Index scores were statistically significantly higher ( $P < .001$ ) for screw-retained ( $0.48 \pm 0.5$ ) than for cemented ( $0.09 \pm 0.3$ ) restorations. The mean marginal bone loss was statistically significantly higher ( $P < .001$ ) for screw-retained ( $1.4 \pm 0.6$  mm) than for cemented ( $0.69 \pm 0.5$  mm) restorations. **Conclusion:** The long-term outcome of cemented implant-supported restorations was superior to that of screw-retained restorations, both clinically and biologically. INT J ORAL MAXILLOFAC IMPLANTS 2011;26:1102–1107

**Key words:** cementation, implant-supported restoration, partial edentulism, screw retention

The use of dental implants in the rehabilitation of partially edentulous patients has become a well established and accepted contemporary clinical method with predictable long-term success.<sup>1,2</sup> There are two different methods of retaining a fixed implant-supported restoration: screw retention and cementation.<sup>3,4</sup> Initially, the choice of method was based on the clinician's preference.<sup>3</sup> The screw-retained prosthesis was originally more popular, because historically it

simplified periodic retrieval of the superstructures and implants for hygiene, repairs, and abutment screw tightening.<sup>5,6</sup> However, occlusal screw holes in a prosthesis can compromise occlusion, porcelain strength, and esthetics.<sup>4</sup> Gradually, improved screw designs and the desire to minimize screw loosening made retrievability issues less important for implant-supported restorations.

Advocates of cemented implant restorations list improved esthetics and occlusion, simplicity of fabrication, reduced cost of components and construction, reduced chairside time, and easier access to the posterior of the mouth as distinct advantages.<sup>4,7–11</sup> Biomechanically, the potential for passivity is higher when a cemented restoration is placed on the implants.<sup>11–14</sup> Moreover, the occlusal surface is devoid of screw holes and, as such, it is easier to develop an occlusion that responds to the need for axial loading. The fact that there is only one screw attaching each abutment to each implant in a cemented design, versus two screws in screw-retained prostheses, reduces the possibility of preload stresses and screw loosening.<sup>15</sup>

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Increased implant treatment predictability and patient demand for high esthetic outcome and lower costs have since modified clinical attitudes regarding cementation.<sup>3,4</sup> However, restorations that use screw retention have been and remain an accepted treatment alternative, particularly in patients with limited interarch space.<sup>16</sup>

Several studies have evaluated the incidence of the most common technical problems with implant-supported fixed partial dentures (FPDs), namely screw loosening, screw fracture, fracturing of veneering porcelain, and framework fracture. Kreissl et al<sup>17</sup> reported, after an observation period of 5 years, a cumulative incidence of screw loosening of 6.7%; in addition, screw fracture occurred in 3.9% of cases, fracture of the veneering porcelain occurred in 5.7% of cases, and fracture of the suprastructure framework was rare (< 1%). Jung et al<sup>18</sup> performed a meta-analysis of the 5-year survival of implant-supported crowns and described the incidence of biologic and technical complications. Survival of implants supporting prostheses was 96.8% after 5 years. The survival rate of crowns supported by implants was 94.5% after 5 years of function. The survival rate of metal-ceramic crowns (95.4%) was significantly higher ( $P = .005$ ) than the survival rate of all-ceramic crowns (91.2%). Peri-implantitis and soft tissue complications occurred adjacent to 9.7% of crowns, and 6.3% of implants had bone loss exceeding 2 mm over the 5-year observation period. The cumulative incidence of implant fractures after 5 years was 0.14%. After 5 years, the cumulative incidence of screw or abutment loosening was 12.7%, and screw or abutment fracture occurred in 0.35% of cases. For suprastructure-related complications, the cumulative incidence of ceramic or veneer fractures was 4.5%. Bragger et al<sup>19</sup> assessed prospectively, over a 10-year period, the incidences of technical and/or biologic complications and failures occurring in a cohort of consecutive partially edentulous patients with fixed reconstructions. The occurrence of loss of retention as a complication increased the odds ratio (OR) for technical failure to 17.6 ( $P < .001$ ). Similarly, the event of a porcelain fracture increased the OR for suprastructure failure at 10 years to 11.0 ( $P \leq .004$ ). Treatment of peri-implantitis increased the OR for biologic failure to 5.44 ( $P \leq .011$ ), compared with implants for which this type of treatment was not applied. They concluded that complications increased the risk for failure.

Eliasson et al<sup>20</sup> evaluated and compared the long-term performance of FPDs supported by two versus three implants. Survival rates for the two- and three-implant-supported prostheses were 96.8% and 97.6%, respectively. The implant survival rate after loading was 98.4% for both groups. The mean bone loss at the 5-year follow-up was 0.3 mm for both groups. No significant

differences in bone loss, implant failure rate, or incidence of mechanical complications were found between the two prosthesis designs. They concluded that the two-implant-supported FPD exhibited long-term clinical performance comparable to that of FPDs supported by three implants. The purpose of the present study was to compare the long-term outcome and complications of cemented and screw-retained implant restorations in partially edentulous patients.

## MATERIALS AND METHODS

### Patient Selection

Consecutive patients attending the Tel-Aviv University School of Dentistry between 1995 and 2009 comprised the study group. The Ethics Committee of Tel Aviv University approved the study protocol. Inclusion criteria were: (1) no systemic contraindication for oral surgical therapy; (2) no parafunctional habits; (3) bilateral partial posterior edentulism; (4) presence of adequate bone width, precluding the need for bone augmentation procedures; (5) opposing arch consisting of either natural teeth or crowns and FPD(s); (6) occlusal relationships allowing for the establishment of a similar occlusal scheme on both sides; and (7) informed consent obtained prior to implant placement.

### Treatment Protocol

In each patient, cemented and screw-retained implant-supported splinted restorations with similar length (two- or three-unit restorations) were randomly assigned to each side of the arch to be treated in a split-mouth design (Fig 1). Internal-hex implants were placed in the molar and premolar areas. Two or three implants were placed to support each restoration. Implant placement was performed in the Department of Periodontics and the Department of Oral and Maxillofacial Surgery at the Tel-Aviv University School of Dentistry with the aid of surgical templates.

At stage-two surgery, 3 to 6 months after implant placement, healing abutments were connected. The final impression was obtained 4 weeks later. Custom impression trays were fabricated with Palatray LC resin (Heraeus Kulzer), which was mixed in accordance with the manufacturer's instructions. The impression trays had windows to allow access for coping screws and had been previously coated with Impregum polyether adhesive (3M ESPE). Prior to every impression procedure, an impression coping was secured to the implant, and the copings were splinted with resin (Pattern Resin, GC). The impression material (Impregum Penta, 3M ESPE) was machine-mixed (Pentamix, 3M ESPE) and part of it was meticulously syringed all around the impression coping to ensure complete coverage of the



**Fig 1** Illustration of the split-mouth study design comparing cemented with screw-retained implant-supported restorations.



**Fig 2** Ceramic fracture of a screw-retained implant-supported restoration.

coping itself. After the impression material had set, the coping screws were unscrewed and the impressions were removed from the patients' mouths. An implant replica was screwed on top of the impression coping, and the impression was poured with type IV artificial stone (New Fujirock, GC) according to the manufacturer's instructions. All laboratory procedures were performed by the same dental laboratory (Shenhav). All prostheses were provided by residents or prosthodontists in the oral rehabilitation department at Tel-Aviv University School of Dentistry.

For the cemented crowns, prefabricated screwed abutments were used for all implants. The abutments were screwed to the implants in the patients' mouths using a screw provided by the manufacturer and a torque wrench that had been calibrated according to the manufacturer's recommendation; regular porcelain-fused-to-metal definitive crowns with porcelain occlusal surfaces were fabricated. A noble alloy (Argelite 60+, Argent) was used for the metal copings, and porcelain (Noritake EX-3, Noritake) was applied in layers to the copings. The occlusal surfaces of the restorations were designed to avoid premature contacts during lateral and protrusive movements. All definitive restorations were cemented with temporary cement (Temp Bond NE, Kerr Italia).

For the screw-retained crowns, the conical abutments were screwed to the implant replicas, and metal copings were waxed directly on the abutments using standard waxing procedures. The waxed copings were then cast using a noble alloy (Argelite 60+, Argent Corp). Porcelain (Noritake EX-3, Noritake) was applied in layers to the cast abutments, carved, and then baked using the manufacturers' recommenda-

tions. The occlusal surfaces of the restorations were designed to avoid premature contacts during lateral and protrusive movements. The crowns were screwed to the conical abutments at the same time in the patients' mouths using a screw provided by the manufacturer and a torque wrench calibrated according to the manufacturer's recommendation. The screw access holes on the occlusal surfaces of the restorations were closed with composite resin (P-60, 3M).

### Follow-up Program

After prosthetic treatment was completed, a follow-up program was carried out for all patients. This provided the opportunity to examine the patients every 6 months in the first year and every 12 months in subsequent years. The following parameters were evaluated and recorded at each recall appointment: ceramic fracture (Fig 2), abutment screw loosening, metal frame fracture, Gingival Index (GI), and marginal bone loss (MBL).

Computerized evaluation of radiographic interproximal bone levels was performed at implant placement, at 6 and 12 months, and every 12 months thereafter.<sup>21</sup> Periapical radiographs were obtained with a dental x-ray machine operating at 70 kVp. Long-cone paralleling projection using a paralleling device (Rinn film holder, Dentsply Rinn) was employed to digitize and analyze the measurements. Film speed group E (Kodak Ektaspeed, Eastman Kodak) was used and developed immediately in an automatic developing machine. Only radiographs that were perpendicular to the long axis of the implants (ie, showing clearly visible implant length) were used for evaluation. The radiographic films were scanned to digital files. Mesial and distal changes in

**Table 1 Comparison of Complications and Clinical Parameters of Screw-Retained and Cemented Implant-Supported Partial Restorations**

Complications/clinical parameters	Screw-retained restoration	Cemented restoration	P
Ceramic fracture	38% ± 0.3%	4% ± 0.1%	< .001
Abutment screw loosening	32% ± 0.3%	9% ± 0.2%	.001
Metal frame fracture	0	0	NS
Mean Gingival Index	0.48 ± 0.5	0.09 ± 0.3	< .001
Mean marginal bone loss (mm)	1.4 ± 0.6	0.69 ± 0.5	< .001

marginal radiographic bone levels were recorded using *ImageJ* for Windows (US National Institutes of Health). *ImageJ* is a public domain Java-based image-processing program based on *NIH Image* that calculates area and pixel value statistics for user-defined selections.<sup>22,23</sup> Spatial calibration was set to express dimensional units in millimeters. The implant-abutment junction served as a reference for radiographic bone levels. The known implant length served as an internal reference for calibration of the measurements. Bone level was measured as the distance from the implant-abutment junction to the crest of the bone.<sup>24</sup> Using the described technique, the actual bone loss was calculated. Assessment of MBL was based on the linear deviation from baseline to the end of the observation period. MBL was assessed by the same operator in all cases.

In addition, the recall program included assessment of GI.<sup>25,26</sup> Patients were examined using dental mirrors and a UNC periodontal probe (Hu-Friedy Mfg). Four surfaces (mesial, distal, midbuccal, midpalatal) on each implant were recorded. The GI was scored as follows: 0 = normal gingiva, no inflammation, discoloration, or bleeding; 1 = mild inflammation, slight color change, mild alteration of gingival surface, no bleeding on pressure; 2 = moderate inflammation, erythema and swelling, and bleeding on pressure; 3 = severe inflammation, erythema and swelling, tendency to spontaneous bleeding, possible ulceration.

### Statistical Analysis

Individual patient data were collected and transcribed into a statistical database. All data were carefully examined for the presence of obvious outliers caused by typing or transcription errors, and these were corrected. All statistical analysis was undertaken using computer software (SPSS, IBM). The means and standard deviations were calculated as summary statistics for all variables. The paired *t* test was used to analyze the numeric data. The results were reported in the form of *P* values and 95% confidence intervals. Significance was accepted at the 5% level.

### RESULTS

Thirty-eight consecutive patients (16 male and 22 female) attending the Tel-Aviv University School of Dentistry between 1995 and 2009 comprised the study group. The mean age of the patients was 58 ± 6 years (range, 38 to 70 years). In all, 221 internal-hex implants (104 in the maxilla, 117 in the mandible) (Biomet 3i, Zimmer Dental, Nobel Biocare, MIS Implant Technologies) were placed. All 221 implants survived the second surgical phase and loading with the definitive restoration. All patients regularly returned to the clinic for recall for up to 15 years. No implant failures were reported during the follow-up period. The mean follow-up periods were 66 ± 47 months for the screw-retained restorations (range, 18 to 180 months) and 61 ± 40 months for the cemented restorations (range, 18 to 159 months). There were no differences in the diameters (4.1 ± 0.3 mm versus 4.1 ± 0.2 mm) or lengths (12 ± 1.1 mm versus 11.9 ± 1.05 mm) of the implants used for screw-retained or cemented restorations.

A comparison of the restorations is summarized in Table 1. Ceramic fracture occurred at a statistically significantly higher rate in screw-retained (38% ± 0.3%) than in cement-retained (4% ± 0.1%) restorations (*P* < .001). Abutment screw loosening occurred statistically significantly more frequently in screw-retained (32% ± 0.3%) than in cemented (9% ± 0.2%) restorations (*P* = .001). Abutment screw loosening occurred in most (86%) cases that presented with ceramic fractures. There were no metal frame fractures for either type of restoration. The mean GI was statistically significantly higher for screw-retained (0.48 ± 0.5) than for cemented (0.09 ± 0.3) restorations (*P* < .001). The mean MBL at the end of the observation period was similar (1.4 ± 0.6 mm) for both mesial and distal sides of the screw-retained restorations. Mean MBL was similar for both sides of the cemented restorations (0.69 ± 0.5 mm) and statistically significantly lower than that seen for the screw-retained restorations (*P* < .001). There was no statistically significant influence (*P* > .05) of the different implant types on biologic or bio-mechanical complications.

## DISCUSSION

The present study provides long-term results (18 to 180 months) of the treatment of 38 patients (221 implants) with implant-supported FPDs using cement or screw retention in a split-mouth design. The comparison of these two different concepts of restoring dental implants with regard to prosthetic complications, peri-implant soft tissue conditions, and peri-implant marginal bone levels revealed significantly different clinical outcomes at the end of the evaluation period.

In implant-supported restorations, stress concentrates at the interface between metal and porcelain, and this interface is greatly influenced by the shape of the metal framework. In screw-retained restorations, the occlusal access hole to the screw represents a locus minoris resistentiae, which may result in ceramic fractures. The occlusal access hole cuts off the structural continuity of porcelain. In contrast, in cemented restorations, the effectiveness of the metal-ceramic bond is not affected by the design of the metal framework.<sup>27–30</sup> In vitro studies<sup>27,29,30</sup> that compared the fracture resistance of implant-supported screw-retained and cemented crowns demonstrated that screw-retained restorations demonstrated a significantly lower resistance to porcelain fracture than cemented crowns. Cemented restorations were more weakly affected by wide paramarginal fractures of the porcelain. In vivo studies indicate that the ceramic fracture rate in partially edentulous patients is 14%.<sup>31</sup> This fracture rate is comparable with the overall ceramic fracture rate observed in the present study (22%). However, a review of the English-language literature revealed no in vivo studies comparing the ceramic fracture rate of screw-retained and cemented restorations. The higher prevalence of ceramic fractures seen in screw-retained restorations in the present study is in agreement with in vitro reports.

Kinsel and Lin<sup>32</sup> evaluated potential statistical predictors for porcelain fracture of implant-supported metal-ceramic restorations. Implant-supported metal-ceramic single crowns and FPDs were found to have a significantly higher risk of porcelain fracture in patients with bruxism habits when a protective occlusal device was not used and when the restoration opposed another implant-supported metal-ceramic restoration.

Abutment screw loosening is a challenging prosthetic complication of implant-supported restorations, ranging in incidence from 3% to 45%.<sup>31</sup> In the present study, abutment screw loosening occurred statistically significantly more often in screw-retained ( $32\% \pm 0.3\%$ ) than in cement-retained ( $9\% \pm 0.2\%$ ) restorations ( $P = .001$ ). These rates are comparable to the existing data. The greater preload exerted by reduced passive fit of the screw-retained framework may explain the greater frequency of abutment screw loosening.<sup>11–15</sup>

The mean GI scores were statistically significantly higher ( $P < .001$ ) for screw-retained ( $0.48 \pm 0.5$ ) than for cement-retained ( $0.09 \pm 0.3$ ) restorations. However, despite the statistically significant differences, the mean GI was low. This reflects that the patient population in the present study had good oral hygiene, which was probably a result of professional support and frequent recall appointments.

The mean MBL at the end of the observation period was statistically significantly greater ( $P < .001$ ) for screw-retained ( $1.4 \pm 0.6$  mm) than for cemented ( $0.69 \pm 0.5$  mm) restorations. A review of the literature yields a mean MBL of 0.9 mm during the first year after loading, followed by 0.1 mm of MBL annually.<sup>31</sup> Therefore, the mean MBL of both types of prostheses in the present study coincides with reports in the literature. The differences in GI may explain the differences in MBL.

## CONCLUSION

Within the limitations of this study, the following conclusions can be made:

1. A higher prevalence of prosthetic complications was observed with screw-retained restorations.
2. The biologic parameters recorded in the present study—marginal bone loss and Gingival Index—were significantly better for cement-retained restorations.

## REFERENCES

1. Lekholm U, Gunne J, Henry P, et al. Survival of the Brånemark implant in partially edentulous jaws: A 10-year prospective multicenter study. *Int J Oral Maxillofac Implants* 1999;14:639–645.
2. Weber HP, Sukotjo C. Does the type of implant prosthesis affect outcomes in the partially edentulous patient? *Int J Oral Maxillofac Implants* 2007;22(suppl):140–172.
3. Taylor TD, Agar JR, Vogiatzi T. Implant prosthodontics: Current perspectives and future directions. *Int J Oral Maxillofac Implants* 2000;15:66–75.
4. Hebel KS, Gajjar RC. Cement-retained versus screw-retained implant restorations: Achieving optimal occlusion and esthetics in implant dentistry. *J Prosthet Dent* 1997;77:28–35.
5. Chee W, Jivraj S. Screw versus cemented implant supported restorations. *Br Dent J* 2006;201:501–507.
6. Sones AD. Complications with osseointegrated implants. *J Prosthet Dent* 1989;62:581–585.
7. Chee W, Felton DA, Johnson PF, Sullivan DY. Cemented versus screw-retained implant prostheses: Which is better? [current issues forum] *Int J Oral Maxillofac Implants* 1999;14:137–141.
8. Keith SE, Miller BH, Woody RD, Higginbottom FL. Marginal discrepancy of screw-retained and cemented metal-ceramic crowns on implant abutments. *Int J Oral Maxillofac Implants* 1999;14:369–378.
9. Preiskel HW, Tsolka P. Telescopic prostheses for implants. *Int J Oral Maxillofac Implants* 1998;13:352–357.
10. Andersson B, Odman P, Lindvall AM, Brånemark P-I. Cemented single crowns on osseointegrated implants after 5 years: Results from a prospective study on CeraOne. *Int J Prosthodont* 1998;11:212–218.

11. Guichet DL, Caputo AA, Choi H, Sorensen JA. Passivity of fit and marginal opening in screw- or cement-retained implant fixed partial denture designs. *Int J Oral Maxillofac Implants* 2000;15:239–246.
12. Karl M, Taylor TD, Wichmann MG, Heckmann SM. In vivo stress behavior in cemented and screw-retained five-unit implant FPDs. *J Prosthodont* 2006;15:20–24.
13. Papavasiliou G, Tripodakis APD, Kamposiora P, Strub JR, Bayne SC. Finite element analysis of ceramic abutment-restoration combinations for osseointegrated implants. *Int J Prosthodont* 1996;9:254–260.
14. Heckmann SM, Karl M, Wichmann MG, Winter W, Graef F, Taylor TD. Cement fixation and screw retention: Parameters of passive fit. An in vitro study of three-unit implant-supported fixed partial dentures. *Clin Oral Implants Res* 2004;15:466–473.
15. Michalakis KX, Hirayama H, Garefis PD. Cement-retained versus screw-retained implant restorations: A critical review. *Int J Oral Maxillofac Implants* 2003;18:719–728.
16. Lewis SG, Llamas D, Avera S. The UCLA abutment: A four-year review. *J Prosthet Dent* 1992;67:509–515.
17. Kreissl ME, Gerds T, Muche R, Heydecke G, Strub JR. Technical complications of implant-supported fixed partial dentures in partially edentulous cases after an average observation period of 5 years. *Clin Oral Implants Res* 2007;18:720–726.
18. Jung RE, Pjetursson BE, Glauser R, Zembic A, Zwahlen M, Lang NP. A systematic review of the 5-year survival and complication rates of implant-supported single crowns. *Clin Oral Implants Res* 2008;19:119–130.
19. Brägger U, Karoussis I, Persson R, Pjetursson B, Salvi G, Lang N. 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.
20. Eliasson A, Eriksson T, Johansson A, Wennerberg A. Fixed partial prostheses supported by 2 or 3 implants: A retrospective study up to 18 years. *Int J Oral Maxillofac Implants* 2006;21:567–574.
21. Turkyilmaz I, Sennerby L, Tumer C, Yenigul M, Avci M. Stability and marginal bone level measurements of unsplinted implants used for mandibular overdentures: A 1-year randomized prospective clinical study comparing early and conventional loading protocols. *Clin Oral Implants Res* 2006;17:501–505.
22. Rasband WS. *ImageJ*. 1997–2005. Bethesda, MD: U.S. National Institutes of Health, 1997–2005. <http://rsb.info.nih.gov/ij/>. Accessed July 29, 2011.
23. Abramoff MD, Magelhaes PJ, Ram SJ. Image processing with *ImageJ*. *Biophotonics Int* 2004;11:36–42.
24. Nowzari H, Chee W, Yi K, Pak M, Chung WH, Rich S. Scalloped dental implants: A retrospective analysis of radiographic and clinical outcomes of 17 NobelPerfect implants in 6 patients. *Clin Implant Dent Relat Res* 2006;8:1–10.
25. Loe H, Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontol Scand* 1963;21:533–551.
26. Silness J, Loe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. *Acta Odontol Scand* 1964;22:121–135.
27. Zarone F, Sorrentino R, Traini T, Di Iorio D, Caputi S. Fracture resistance of implant-supported screw- versus cement-retained porcelain fused to metal single crowns: SEM fractographic analysis. *Dent Mater* 2007;23:296–301.
28. Shillingburg HT, Hobo S, Whitsett LD, Jacobi R, Brackett SE. *Fundamentals of Fixed Prosthodontics*. Chicago, IL: Quintessence, 1997:455–483.
29. Torrado E, Ercoli C, Al Mardini M, Graser GN, Tallents RH, Cordaro L. A comparison of the porcelain fracture resistance of screw-retained and cement-retained implant-supported metal-ceramic crowns. *J Prosthet Dent* 2004;91:532–587.
30. Karl M, Graef F, Taylor TD, Heckmann SM. In vitro effect of load cycling on metal-ceramic cement- and screw-retained implant restorations. *J Prosthet Dent* 2007;97:137–140.
31. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. *J Prosthet Dent* 2003; 90:121–132.
32. Kinsel RP, Lin D. Retrospective analysis of porcelain failures of metal ceramic crowns and fixed partial dentures supported by 729 implants in 152 patients: Patient-specific and implant-specific predictors of ceramic failure. *J Prosthet Dent* 2009;101:388–394.