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ORIGINAL ARTICLE

Clinician- and patient-reported long-term evaluation of screw- and cement-retained implant restorations: a 5-year prospective study

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Abstract The purpose of this study was to evaluate the survival and success of screw- versus cement-retained implant crowns over a 5-year period. This was a multicenter prospective cohort study, consisting of patients who had ≥1 dental implant placed and restored in the anterior maxilla over a 5-year period. The primary predictor variable was the type of restoration (screw- versus cement-retained). The outcome variables were clinician- or patient-reported measures related to soft tissue and restoration quality. Descriptive and bivariate statistics were computed to compare the screw- versus cement-retained groups. Kaplan–Meier statistics were computed for implant survival. Information was collected for 102 patients who had 214 implants placed during the study period. Complete data, amenable to analysis, were available for 99 (97.1%) patients and 193 (90.2%) implants. The restorations were approximately evenly divided between screw- (53.4%) and cement-retained (46.6%). Approximately 49% of patients in the sample were female; the sample's mean age was 47.3± 13.9 years; each patient had an average of 2.0±1.0 implants placed and restored. The mean time from prosthesis placement (definitive) to study endpoint was 61.9± 10.6 months. The overall implant survival rate was 96.4%, with no statistically significant difference in survival between the screw- and cement-retained groups (p=0.45). The majority of clinician- and patient-assessed outcomes were similar. The results of this study indicate that for the majority of clinician- and patient-assessed success parameters screw- and cement-retained restorations are equivalent in the anterior maxilla.

Keywords Dental implant · Screw-retained restoration · Cement-retained restoration · Peri-implant soft-tissue health

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Introduction

The majority of studies examining implant success and survival have emphasized the integrity of implant-bone support and the quality of osseointegration, typically evaluated using parameters such as implant mobility, inflammation or infection around the implant site, and peri-implant-bone loss [1–5]. While these studies have served to establish quantitative and descriptive methodologies for evaluating implant success, they do not fully address functional requirements for osseointegrated implants, and do not account substantially for esthetics or soft-tissue health. As implant therapy evolves and becomes standard of care, and the population seeks out alternatives to traditional fixed partial dentures for treatment of edentulous areas within the esthetic zones, success of dental implants will be dependent upon more than simply osseointegration. The long-term success of dental implants will need to be assessed using functional requirements (including, but not limited to, osseointegration) and esthetic requirements, which are inextricably associated with peri-implant soft-tissue architecture.

A number of studies have suggested that peri-implant soft-tissue health can influence implant survival [6–13]. These studies have shown that the bacterial loads associated with failing dental implants are the same organisms implicated in periodontal disease [6, 7] and that pro-

inflammatory mediators associated with soft-tissue inflammation are differentially expressed in tissues surrounding failing implants versus healthy implants [9, 14].

While it is clear from the present body of literature that the health of peri-implant soft tissues can have an effect on the stability of peri-implant bone, it is not clear whether different types of implant restorations have differential effects on soft tissues. The association between tooth-supported prostheses and soft-tissue health has been evaluated extensively [15–24]. Most studies for tooth-supported prostheses indicate that the major contributing factor for soft-tissue compromise (as a result of plaque accumulation, gingival inflammation, and/or periodontal disease) for these types of restorations is defective sub-gingival margins. An overhanging margin can impinge on the surrounding soft tissues, leading to irritation, inflammation, and tissue lysis [20, 21]. Likewise, the presence of a marginal gap located sub-gingivally has been demonstrated to influence soft-tissue health and implant survival, as the gap size can be associated with the accumulation of plaque and debris, ultimately leading to inflammation and loss of tissue architecture [25–29]. In vitro studies have indicated that the marginal discrepancy at the implant/crown interface was statistically significantly less for screw-retained crowns versus cement-retained crowns, both before and after cementation [30–32]. Additional in vitro investigations have suggested that, due to the presence of the screw hole, screw-retained implant restorations may be less resistant to fracture than cement-retained restorations [33].

A recent 3-year analysis of peri-implant soft-tissue health surrounding screw- versus cement-retained implant restorations found that standard soft tissues parameters (sulcular bleeding, plaque accumulation) were more favorable around screw-retained prostheses [34]. The purpose of the present study is to evaluate the survival and success of screw- versus cement-retained implant crowns over a 5-year period using standard measures of soft-tissue integrity (sulcular bleeding, modified plaque score and gingival levels). In addition, using a semi-quantitative scale, patient- and clinician-assessed esthetics for the two study groups will be appraised. Finally, the quality of the soft tissues over the 5-years, implant and prosthesis survival up to 5 years and any associations between soft-tissue health and implant survival will be evaluated. We hypothesize that soft tissue health will be better around screw-retained restorations, compared with cement-retained restorations, and that clinician- and patient-assessed outcomes will be more favorable for cemented restorations.

Materials and methods

Study design This was a multi-center prospective cohort study, enrolling a sample of patients who had ≥1 missing teeth in the anterior maxilla that were replaced by screw- or cement-retained porcelain fused to metal prosthesis placed on Straumann® ITI Hollow Cylinder Dental implants. The decision to use screw- versus cement-retained restorations following implant placement was left to the discretion of the restoring clinician. For screw-retained restorations, the Straumann® Octa-Abutment system was used. For cement-retained restorations Straumann® solid abutments of either 4, 5.5, or 7 mm length were used and various cements were used—the choice of cement was left to the discretion of the restoring clinician. Access holes were closed with a temporary material such as soft light curing composite (Fermit®) or Cavit® over a cotton or teflon pellet to cover the screw head. All sites utilized the same protocol and definitions for outcome evaluation, and measuring instrumentation was standardized and calibrated to ensure comparability between measurements at different study sites. The study population included 102 patients who had implants placed during the period of July 1995–July 2000, were ≥18 years of age, had sulcular bleeding scores (sulcular bleeding index (SBI): 0=no bleeding on probing−3=heavy bleeding on probing) ≤1 and modified plaque scores (modified plaque index (MPI): 0=no plaque accumulation evident on probing−3=visible plaque accumulation) ≤1, had adequate bone volume at implant site, and no evidence of residual roots or pathology at the implant site. Patients were excluded if they had one or more of the following conditions: smoker (≥10 cigarettes/day), substance abuse history, severe bruxing or clenching habits, untreated periodontitis, systemic disease (endocrine, renal, hematologic, hepatic, immunosuppressive), current steroid/chemotherapy, head and neck irradiation, previous bone augmentation, or the use of an investigational drug within the last 30 days. All patients had completed informed consent. The Institutional Review Boards involved in the study had approved the study protocol prior to patient enrollment.

Study variables Study variables were categorized as predictor variables or outcome variables. Predictor variables included type of prosthesis (screw- or cement-retained), gender, age, and number of implants placed. Outcome variables were divided into soft-tissue outcome variables and restorative outcome variables. Soft-tissue outcome variables were MPI, SBI, keratinized mucosa and gingival levels, and a subjective measurement of esthetic quality. MPI and SBI values were measured for each of four implant surfaces (mesial, distal, labial, and palatal) and ranged from 0 (MPI, no plaque accumulation; SBI, no bleeding on probing) to 3 (MPI, visible plaque accumulation; SBI: heavy bleeding on probing) [33]. Measures of gingival attachment included width of keratinized mucosa (KM) and gingival level (GL). KM

was evaluated by measuring the width (mm) of the keratinized tissue on the mid-labial aspect of the implant area. GL was defined as the distance from the most coronal portion of the gingival margin to the top of the implant collar (positive values indicate sub-gingival margins, negative values indicate supragingival margins —given the location of the prostheses in this study, a positive value is considered to be a good outcome). Esthetic fulfillment was evaluated by both the patient and clinician using a semi-quantitative Likert-type scale ranging from 1 (excellent) to 4 (poor). Using this scale, patients were asked to evaluate comfort, appearance, fit, chewing, and overall satisfaction. Restorative outcome variables were subjectively evaluated by the treating clinicians and included retention, stability and esthetics. Retention of the prosthesis was measured by evaluating any displacement of the prosthesis along the path of insertion during functional and excursive movements. Stability was measured by manual testing for any movement of the prosthesis in response to manual pressure. Esthetics was assessed according to the clinician's opinion of how well the prosthesis met their expectations for a successful prosthesis in the anterior maxilla. Patients were given a questionnaire that asked specific questions regarding the fit of the prosthesis. A secondary outcome variable was implant survival and associated implant complications.

During the course of the study, data were collected pre-surgically, at time of implant placement (time 0), time of definitive prosthesis placement (4–6 months post-implant placement), at 3 months post-prosthesis placement, and at 60-months post-prosthesis delivery. Outcome analyses were performed for data at baseline (prosthesis delivery), 3-month follow-up, and study endpoint (60 months). Regarding prosthesis type, 96% of the crowns were porcelain fused to base metal and 4% were all ceramic.

Statistical analyses Data were collected prospectively over the course of the study and entered into a statistical database for analysis (SPSS v.11.0, © SPSS Inc., Chicago, IL). Because of the lack of confirmed normality within the dataset, non-parametric methods were used to analyze the data. Descriptive statistics were computed to provide a general description of the patient sample and to ensure comparability between the screw- and cement-retained groups. Bivariate statistics were computed to evaluate associations between the prosthetic group and the soft-tissue and restorative outcome variables. Kaplan–Meier estimates were used to compare implant survival rates between the screw- and cement-retained groups. For all analyses, a p value ≤ 0.05 was considered statistically significant.

Results

Over the study period, 102 patients (having 214 implants) met the criteria for inclusion in the study. Complete data were available for 99 patients (97.1%) and 193 implants (90.2%). Approximately, 49% of the patients in the sample were female; the mean age of the sample was 47.3± 14.9 years. On average, patients in the sample have 2.0±1.0 implants placed. Prostheses were approximately evenly distributed between screw-retained (53.4%) and cement-retained (46.6%) restorations. The mean time between prosthesis delivery and final follow-up was 61.9± 9.6 months. There were no statistically significant differences between the screw- and cement-retained groups with regard to any of the predictor variables ($p \geq 0.07$).

Overall implant survival and soft-tissue outcomes are summarized in Table 1. The MPI scores were not statistically significantly different between the two groups at baseline, but were statistically significantly different at 3 and 60 months ($p \leq 0.05$). The mean SBI scores were statistically significantly greater for the cement-retained group at all time points ($p \leq 0.05$).

Measures of soft-tissue attachment included the width of keratinized tissue and gingival level. There were no statistically significant differences in the width of keratinized tissue between the screw- and cement-retained groups. The mean gingival levels were also comparable for the screw- and cement-retained groups both at 3 and 60 months ($p \geq 0.05$).

Implant survival, defined as lack of implant mobility, peri-implant radiolucency, infection, or bone loss, was 96.4% and was not statistically significantly different for screw- (95.2%) versus cement-retained (97.8%) restorations ($p=0.43$).

Clinician-assessed outcomes are summarized in Table 2. There were no statistically significant differences between the screw- and cement-retained groups with regard to clinician-assessed retention over the study period. In addition, there were no statistically significant differences between the two groups with regard to stability or esthetics.

Patient-assessed outcomes are summarized in Table 3. A statistically significantly higher proportion of patients reported excellent comfort with cement-retained prostheses compared to screw-retained prosthesis, both at the time of delivery and at the study endpoint ($p \leq 0.05$). Patients with cement-retained restorations reported statistically significantly higher satisfaction with prosthetic appearance for cement-retained restorations on the date of cementation ($p=0.04$); however, there were no statistically significant differences in appearance scores at 60 months ($p \geq 0.05$). There was a relatively weak correlation between clinician- and patient-assessed esthetics (Spearman's rho=0.14, $p=0.05$). There were no statistically significant differences

Table 1 Implant survival and soft tissue outcomes

Outcome	Screw-retained ($n1=103$)	Cement-retained ($n2=90$)	p value[a]
Soft-tissue outcomes			
Modified Plaque Score (MPI)			
Prosthesis delivery (0 months)	0.15±0.41	0.12±0.28	0.86
Follow-up (3 Months)	0.12±0.39	0.18±0.30	0.01
Study endpoint (60 months)	0.12±0.28	0.22±0.35	0.02
Sulcus Bleeding Index (SBI)			
Prosthesis delivery (0 months)	0.09±0.32	0.27±0.45	<0.01
Follow-up (3 months)	0.10±0.34	0.18±0.36	0.01
Study endpoint (60 months)	0.08±0.21	0.37±0.52	<0.01
Width keratinized tissue (mm)			
Prosthesis delivery (0 months)	4.7±1.4	4.8±1.5	0.47
Follow-up (3 months)	4.9±1.1	5.1±1.5	0.40
Study endpoint (60 months)	5.1±4.0	4.5±1.2	0.34
Gingival level (mm)			
Prosthesis delivery (0 months)	1.0±1.1	1.5±1.4	<0.01
Follow-up (3 months)	1.1±1.0	1.1±1.5	0.77
Study endpoint (60 months)	2.6±6.7	2.5±6.6	0.89
Overall implant survival	98 (95.2)	88 (97.8)	0.45

[a] Given the lack of confirmed normality within the dataset, p values were calculated using non-parametric methods (Mann–Whitney U test). Overall implant survival rates were compares using Kaplan–Meier analyses

in patient assessed fit ($p\geq0.05$), chewing ($p\geq0.05$), or overall satisfaction ($p\geq0.05$) between the two prosthetic groups. Notably, the majority of patients in both groups reported excellent overall satisfaction with the restorations (≥84.7%), particularly at 60 months (≥93.2%).

Discussion

The purpose of this study was to evaluate the health of peri-implant soft tissues surrounding screw- and cement-retained restorations at 5 years post-insertion. We hypothesized that, due to the potentially larger marginal discrepancy between the cement-retained crown and implant collar seen in vitro, and the additional irritant effects of cement, that soft-tissue quality would be higher around screw-retained restorations, whereas that clinician- and patient-assessed outcomes would be more favorable for cemented restorations.

With regard to soft tissue parameters, there were no statistically significant differences in the width of keratinized gingiva or gingival levels at 5 years. Cement-retained restorations had statistically significantly higher MPI and SBI scores at 5 years. MPI and SBI scores were highly correlated (rho=0.41; $p\leq0.01$). One plausible explanation for this observation is that the marginal discrepancy associated with cement-retained restorations leads to gingival irritation, which subsequently manifests as bacterial accumulation (plaque) and inflammation (bleeding). Though this may seem to be a significant

Table 2 Clinician-assessed outcomes

Clinician-assessed outcomes	Screw-retained ($n1=103$)	Cement-retained ($n2=90$)	p value[a]
Retention (excellent)			
Prosthesis delivery (0 months)	96.1	94.4	0.58
Follow-up (3 months)	92.2	92.2	1.00
Study endpoint (60 months)	100	98.9	0.29
Stability (excellent)			
Prosthesis delivery (0 months)	96.1	94.4	0.58
Follow-up (3 months)	92.2	92.2	1.00
Study endpoint (60 months)	98.1	98.9	0.64
Esthetics (excellent)			
Prosthesis delivery (0 months)	73.8	63.3	0.12
Follow-up (3 months)	70.9	65.6	0.44
Study endpoint (60 months)	84.5	80.9	0.42

[a] Given the lack of confirmed normality within the dataset, p values were calculated using non-parametric methods (Mann–Whitney U test)

Table 3 Patient-assessed outcomes

Patient-assessed outcomes	Screw-retained ($n1=103$)	Cement-retained ($n2=90$)	p value[a]
Comfort (excellent)			
Prosthesis delivery (0 months)	80.8	90.9	0.04
Follow-up (3 months)	83.2	78.8	0.57
Study endpoint (60 months)	92.2	98.9	0.03
Appearance (excellent)			
Prosthesis delivery (0 months)	83.8	87.5	0.04
Follow-up (3 months)	84.2	76.5	0.26
Study endpoint (60 months)	93.2	87.8	0.2
Fit (excellent)			
Prosthesis delivery (0 months)	83.8	90.9	0.11
Follow-up (3 months)	83.2	85.9	0.68
Study endpoint (60 months)	99	100	0.35
Chewing (excellent)			
Prosthesis delivery (0 months)	88.3	89.7	0.67
Follow-up (3 months)	86.3	84.7	0.83
Study endpoint (60 months)	96.1	98.9	0.23
Overall satisfaction (excellent)			
Prosthesis delivery (0 months)	89.9	94.3	0.20
Follow-up (3 months)	89.5	84.7	0.38
Study endpoint (60 months)	93.2	96.7	0.28

[a] Given the lack of confirmed normality within the dataset, p values were calculated using non-parametric methods (Mann–Whitney U test)

detrimental effect of cement-retained restorations, the absolute MPI and SBI scores were low for both screw- and cement-retained restorations (mean scores <1 for both groups at all time points). Such low scores, while statistically significantly different, are unlikely to be clinically consequential.

There were no significant differences with regard to clinician-assessed parameters between the two groups over the study period. However, both groups showed a statistically significant improvement in clinician-assessed retention and esthetics.

For patient-assessed outcomes, patients reported greater levels of comfort with cement-retained restorations and they were more satisfied with prosthetic appearance at placement with cement-retained restorations. However, these differences disappeared at long-term evaluation, as there was no statistically significant difference in overall satisfaction for cement- versus screw-retained restorations at 5 years.

Finally, the overall implant survival rate was 96% in the anterior maxilla and was not statistically significantly different between the screw- and cement-retained groups.

The results presented here confirm those of previous studies evaluating patient satisfaction with implant restorations [35, 36]. In a retrospective study, Vermylen et al. studied patient satisfaction and quality of single-tooth restorations [35]. Subjects were sent questionnaires on their opinions of the restorations esthetics, phonetics and overall satisfaction following a mean loading period of 33 months. The patients were very positive regarding the esthetics, phonetics, comfort and satisfaction, with 85% reporting that they would have the procedure again and 100% reporting that they would recommend the procedure to a future patient. Clinician-assessment scores were also positive, with the majority of restorations (80%) being marked as acceptable or excellent. A similar prospective study, using a 13-question visual analog scale (VAS) demonstrated that over 90% of patients were completely satisfied with their treatment [36].

There are several limitations to the study which may be categorized as selection bias, a reduced sample size/low failure rate, statistically insignificant results and no radiographic marginal bone levels or implant stability measurements. With regard to selection bias (loss to follow-up bias), the loss to follow-up was only 3%. While we cannot make any claims about the status of the restorations for these patients, this rate of loss is not substantial by epidemiologic standards. Finally, the type of implant used herein is no longer a mainstay of implant treatment. While this may be a limiting factor, it is unlikely to be significantly consequential, as the primary purpose of this study was to evaluate the effect of the restoration on soft tissue health. In addition, the implant survival rates reported herein are consistent with those from other reports, using different types of implants, suggesting that the type of implant used herein is no more likely to fail [37].

The lack of statistical significance with regard to many outcomes may be due to a moderate sample size and baseline high survival rates of endosseous implants and

implant-supported restorations. Thus, the effect size may be too small to detect in the study sample herein. We would require a larger sample to have a sufficient number of failures to perform a stratified analysis for risk factors for failure.

Conclusion

The results of this study suggest that soft tissue health may be better around screw-retained implant restorations, though the mean SBI and MPI scores were <1 for both groups. For the patient, there were no differences in satisfaction between the two types of restorations. The overall 5-year implant survival rate was 96% in the anterior maxilla, with no differences between screw- and cement-retained restorations. Future studies will be directed at formulating a quantitative scale for the assessment of restoration quality using a composite scoring of stability, esthetics, and retention which could possibly ameliorate the discrepancy between clinician-assessed success and patient-assessed success utilizing VAS scoring.

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Conflict of interest The authors declare that they have no conflict of interest.

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