Investigation of the Association Between Cement Retention and Prevalent Peri-Implant Diseases: A Cross-Sectional Study

Georgios A. Kotsakis,* Lei Zhang,† Philippe Gaillard,‡ Michael Raedel,§ Michael Horst Walter,§ and Ioannis K. Konstantinidis§

Background: The aim of this study is to examine the association between retention type (cement-retained versus screw-retained restorations) and prevalence of peri-implant diseases in a German university-treated population.

Methods: Data were analyzed from individuals that underwent clinical and radiographic peri-implant examinations as part of a university-based cross-sectional study from September 2011 to October 2012.

Results: Data from 139 individuals (mean age: 57.59 years) having 394 implants were analyzed: 192 implants supporting single crowns and 202 fixed partial dentures. Overall, 11.9% of the participants had peri-implantitis, whereas 68.9% had peri-implant mucositis. Crude odds ratios (95% confidence intervals) for peri-implantitis and peri-implant mucositis for cement- versus screw-retained restorations were 1.43 (0.45, 4.60) and 0.89 (0.53, 1.48), respectively. Results remained non-significant in multivariable models adjusting for type of restoration and smoking (all *P* values >0.50). There was also no effect of splinting restorations on disease prevalence in adjusted analyses (*P* values >0.32).

Conclusions: In this university-treated sample, there is no association between the type of prosthesis retention and peri-implant diseases. Current findings show that, when appropriate selection and removal of cement is performed, cement retention is not a risk indicator for peri-implant diseases. *J Periodontol 2016;87:212-220.*

KEY WORDS

Cross-sectional studies; dental cements; dental implants; dental prosthesis, implant-supported; mucositis; peri-implantitis.

* Department of Periodontology, University of Washington, Seattle, WA.
† Biostatistical Design and Analysis Center, University of Minnesota, Minneapolis, MN.
‡ Currently, Department of Mathematics and Statistics, Auburn University, Auburn, AL; previously, Biostatistical Design and Analysis Center, University of Minnesota.
§ Department of Prosthodontics, Dresden University of Technology, Dresden, Germany.

The dawn of the implant era in dentistry has generated an endless debate among clinicians on the ideal type of implant prosthesis retention. Historically, screw-retained restorations were first introduced for use with osseointegrated titanium implants, but the ease of restorability along with a wider margin for error in implant positioning allowed cement-retained restorations to dominate during the 2000s.[1,2] Meticulous review of the literature shows that attempts have been made to define specific indications for use of one type of retention in lieu of the other.[3] However, distinct schools of thought exist that favor one type of restoration-to-fixture retention versus the other.[4] It is not uncommon for groups of clinicians to use solely one type of retention in the majority of their clinical cases rather than attempting to personalize treatment planning.[4]

Under the light of contemporary evidence that underlines the moderately high frequency of peri-implant diseases in patients undergoing implant treatment, the risk of occurrence of disease between different types of retention has become a question of interest.[5] The effect of residual cement on the initiation of the inflammatory cascade that may eventually lead to peri-implantitis around osseointegrated implants has

doi: 10.1902/jop.2015.150450

been elucidated clearly, thus implying a causal effect of excess cement on the development of peri-implant diseases.[6] These findings have led to increased awareness in the dental community against cement-retained restorations.[7] The speculation that cement-retained restorations may be associated with an increased prevalence of peri-implantitis harbors the risk of promoting screw-retained restorations as a panacea.[6] To date, there is limited information assessing the effect of the type of prostheses retention on the prevalence of peri-implant diseases.

The primary aim of this study is to examine the association between retention type (cement-retained versus screw-retained restorations) and prevalence of peri-implant diseases in a population of individuals that underwent implant treatment at a university clinic. The effect of splinting of restorations on the prevalence of peri-implant disease was also assessed as a secondary outcome.

MATERIALS AND METHODS

Participant Selection

Patient recruitment and data collection were performed at the Department of Prosthetic Dentistry, Dresden University of Technology, Dresden, Germany. The responsible ethics committee of the university approved the study protocol (approval EK255072011). All participants signed an informed consent, and all study procedures were performed according to the principles of the Declaration of Helsinki for medical studies. After data collection, de-identified data were analyzed at the biostatistics core of the Clinical and Translational Institute, University of Minnesota, Minneapolis, MN. Reporting was performed based on the recommendations of the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) initiative.[8] Results on the methods and sample selection of this cross-sectional study have been reported previously.[9] Briefly, the participant population consisted of individuals (58 males and 77 females, aged 57.59 ± 15.36 years) with implant-supported restorations who attended a follow-up visit in a university clinic for maintenance care from September 2011 to October 2012.[9]

Participants were included if they presented with at least one implant-supported restoration in occlusion during the evaluation at their maintenance appointment. All implants were placed previously in the same university setting and were all restored according to the protocol of the Prosthodontics Clinic. Briefly, the protocol for screw-retained prostheses included torqueing of the prostheses according to the instructions of each manufacturer, occlusion of the access hole with Teflon tape, and sealing with composite resin.‖ For cement-retained prostheses, abutment selection was performed in close collaboration with the dental technician to ensure that the restoration–abutment interface was 0.5 to 1 mm below the mucosal level and in no case exceeding 1.5 mm submucosal to allow access for cement removal.

The abutments were torqued onto the implants, and the screw holes were sealed with gutta-percha.¶ For cementation, either zinc phosphate cement# or zinc oxide non-eugenol cement** was used. Both types of cement were mixed according to the instructions of the manufacturer and applied in a thin film of ≈2 mm at the cervical margin of the internal surface of the crown using a microbrush.†† The crowns were then seated onto the abutments with finger pressure, and excess cement was removed using curets,‡‡ super floss,§§ and dental floss‖‖ under ×3 to ×4 magnification with dental loupes.

Individuals were excluded from participation if they fulfilled one or more of the following criteria: 1) antibiotic therapy for any medical or dental reason ≤2 months before the examination; 2) <12 months of follow-up postloading; 3) restorations that did not allow for proper assessment of implant probing depth (PD); 4) removable implant-supported restorations; 5) history of infectious diseases; and 6) participants unable or unwilling to sign the informed consent form.

Assessment of Outcomes

Clinical examination was performed in the Department of Prosthodontics, Dental School, Dresden University of Technology by the same examiner (IK) in all cases, as described previously.[9] The examination included assessment of the retention (screw versus cement) and restoration type (single versus splinted), full-mouth plaque records (PRs), bleeding on probing (BOP), and PD around implants. PR was assessed by recording the presence of plaque at six sites (mesio-facial, midfacial, facial, disto-facial, and respective lingual/palatal sites) around each implant and the teeth.[10] A score of 0 was given when there was no plaque on the tooth or implant surface and 1 when plaque was detected on the surface of the tooth or implant. BOP was also evaluated at six sites per implant/tooth. A periodontal probe¶¶ was inserted into the sulcus of the teeth and the implants and was run parallel to their longitudinal axis. The presence of bleeding was assessed at least 15 seconds after probing. As for the PR, BOP was also assessed as a binary (0,1) outcome.

‖ Filtek, 3M ESPE, Seefeld, Germany.
¶ Coltene, Langenau, Germany.
# Harvard Cement, Harvard Dental International, Hoppegarten, Germany.
** TempBond NE, Kerr, Anaheim, CA.
†† Microbrush International, Grafton, WI.
‡‡ Hu-Friedy, Chicago, IL.
§§ Oral-B, Proctor & Gamble, Cincinnati, OH.
‖‖ Oral-B, Proctor & Gamble.
¶¶ PCP-UNC 15 periodontal probe, Hu-Friedy.

Similar to PR and BOP, PD was measured at six surfaces around each implant. The measurements were performed with a graded periodontal probe.## All measurements were rounded to the nearest millimeter. Effort was made to position the periodontal probe with an angle of ≤15° to the axis of the implant to avoid overestimation of PD. If the contour of the suprastructure hindered appropriate positioning of the probe or if the angle of the probe exceeded 30°, then the sites were excluded from the analysis.

Radiographic examination was also performed for implants with PD ≥5 mm to assess potential peri-implant bone loss. Intraoral radiographs were taken with a dental x-ray machine using the long-cone paralleling technique and Eggen film holders. The radiographs were analyzed digitally using an imaging software program.*** Calibration was performed using the length of the implant as a fixed reference point to compensate for potential foreshortening or elongation of the radiograph, as described previously.[11] Vertical bone loss was recorded at the mesial and distal surfaces of the implant by measuring the distance from the implant platform to the first bone-to-implant contact. The same calibrated examiner (IKK) performed all radiographic measurements.[9] In addition to clinical and radiographic data, participants' demographic characteristics and smoking status records (current smokers, former smokers, non-smokers) were collected and used in subsequent analyses.

Definition of Health/Disease Status

The diagnostic criteria reported previously by Ferreira et al.[12] for the definition of peri-implantitis and peri-implant mucositis were used.

Peri-implant mucositis was defined as at least one implant surface with positive BOP. Peri-implantitis was diagnosed if an implant had simultaneously one surface with positive BOP, PD ≥5 mm, and radiographically detectable bone loss ≥2 mm. This definition included all the necessary components for defining a peri-implantitis case as recommended by Lang and Berglundh[13] and confirmed by the VIII European Workshop on Periodontology:[14] the presence of BOP, changes in crestal bone level, and deepening of periodontal pockets. A person was considered as healthy only if all their implants were free of disease. Otherwise, they were considered as having peri-implant mucositis or peri-implantitis based on the level of disease of their most diseased implant.

Statistical Analyses

Descriptive statistics were expressed as means ± SD, frequencies, or percentages, as appropriate for demographic characteristics and clinical parameters at implant and person levels. Classification of disease was performed using a three-level definition (peri-implant health, peri-implant mucositis, or peri-implantitis) of peri-implant disease, based on the case definitions described above. A two-level definition of disease (peri-implant mucositis or peri-implantitis versus health) was also used to assess the overall effect of retention/restoration on peri-implant diseases.

For person-level comparisons, two-sample *t* tests were used for continuous variables, and Fisher exact tests were used for categorical variables. All implant-level analyses were performed via generalized estimating equations (GEEs) with robust standard errors and a Gaussian or logit link, depending on the outcome, to account for intraperson correlation attributable to multiple implants nested within each patient. To assess the primary and secondary outcomes for this study, two nominal, independent variables (type of retention: cement versus screw; type of restoration: single versus splinted, respectively) were investigated for their association with peri-implant diseases based on both three-level disease (peri-implant health, peri-implant mucositis, or peri-implantitis) and two-level disease (peri-implant mucositis or peri-implantitis versus health) definitions. Associations after controlling for important covariates were also examined. Odds ratios (ORs) and their 95% confidence interval (CI) were reported. *P* values are two sided and calculated at $\alpha = 0.05$. All analyses were performed using a statistical software package.†††

RESULTS

From a total of 191 eligible persons, 186 consented to clinical examination and were enrolled in this cross-sectional study (for detailed description of the selection process, see Konstantinidis et al.[9]). Data from 139 individuals (Table 1) were used for the present analysis after excluding 47 that were rehabilitated with removable prostheses supported by locator, ball-o-ring, or bar retention. Four of these 139 included individuals who were restored with both removable and fixed restorations and were also excluded from the analysis. In total, 394 implants in 135 patients were evaluated (see supplementary Fig. 1 in online *Journal of Periodontology*). Among them, 192 implants supported single crowns and 202 were fixed partial dentures. The mean follow-up time was 5.5 years.[9] Baseline data regarding demographic characteristics, clinical findings, and information on potential confounders are summarized in Table 1.

PCP-UNC 15 periodontal probe, Hu-Friedy.
*** Sidexis XG, Sirona Dental Systems, Bensheim Germany.
††† SAS v.9.3, SAS Institute, Cary, NC.

Table 1.

Person-Level Summary of Demographic Characteristics and Disease Prevalence

		Retention Type*			Restoration Type†		
	Overall (n = 135)	Screw (n = 83)	Cement (n = 31)	P‡	Single (n = 69)	Splinted (n = 45)	P‡
3-level disease status, n (%)							
Peri-implantitis	16 (11.85)	8 (9.64)	4 (12.90)	0.896	8 (11.59)	6 (13.33)	0.021
Peri-implant mucositis	93 (68.89)	56 (67.47)	21 (67.74)		40 (57.97)	36 (80.00)	
Health	26 (19.26)	19 (22.89)	6 (19.35)		21 (30.43)	3 (6.67)	
2-level disease status, n (%)							
Peri-implant disease	109 (80.74)	64 (77.11)	25 (80.65)	0.802	48 (69.57)	42 (93.33)	0.008
Health	26 (19.26)	19 (22.89)	6 (19.35)		21 (30.43)	3 (6.67)	
Age in years, mean (SD)	57.59 (15.36)	56.57 (15.32)	57.10 (15.32)	0.871	55.07 (16.89)	57.87 (14.06)	0.069
Sex, n (%)							
Females	77 (57.04)	46 (55.42)	18 (58.06)	0.835	40 (57.97)	27 (60.00)	0.349
Males	58 (42.96)	37 (44.58)	13 (41.94)		29 (42.03)	18 (40.00)	
Smoking status, n (%)							
Current smoker	19 (14.07)	11 (13.25)	5 (16.13)	0.687	11 (15.94)	6 (13.33)	0.872
Former smoker	11 (8.15)	7 (8.43)	1 (3.23)		5 (7.25)	4 (8.89)	
Non-smoker	105 (77.78)	65 (78.31)	25 (80.65)		53 (76.81)	35 (77.78)	

* n = 21 have both screw and cement retentions and are excluded from the person-level summary.
† n = 21 have both splinted and single restorations and are excluded from the person-level summary.
‡ For continuous variables, *P* values arise from one-way analysis of variance; for categorical variables, *P* values are calculated from Fisher exact test.

Retention Type and Prevalent Disease

Overall, 11.9% of the participants had peri-implantitis, whereas 68.9% had peri-implant mucositis (Table 1). Implant level estimates were 5.6% for peri-implantitis and 57.11% for peri-implant mucositis (Table 2). Crude ORs (95% CIs) for peri-implantitis and peri-implant mucositis for cement-retained versus screw-retained restorations were 1.43 (0.45, 4.60) and 0.89 (0.53, 1.48), respectively (Table 3). Results remained non-significant in multivariable models adjusting for type of restoration and smoking at the time of implant insertion (all *P* values >0.5). No association between type of retention and peri-implant diseases was also found in the model considering a two-level definition of disease with an OR of 0.91 (0.53, 1.55) in the fully adjusted model.

Restoration Type and Prevalent Disease

In the present sample population, 13.3% of persons with splinted restorations were diagnosed as having peri-implantitis compared to 11.6% of participants with single restorations (Table 1). For peri-implant mucositis, the prevalence recorded was 80.0% versus 58.0% among participants with splinted versus single restorations, respectively (Table 1). In multivariable analysis, there was no significant effect of restoration type on peri-implant diseases (all *P* values >0.32) (Table 3). The adjusted ORs for peri-implantitis and peri-implant mucositis among single versus splinted restorations were 0.63 (0.23, 1.76) and 0.87 (0.54, 1.40), respectively (Table 3, model 3). Results did not differ when the two-level definition of disease was used (Table 3).

Additional Confounder Adjustment

No difference in the age distribution or sex was found in subgroups defined by retention or restoration type, so age and sex were not included in our disease models (Table 1). To be consistent with previous epidemiologic studies that have identified smoking as a risk factor for peri-implantitis, smoking was included as a covariate to the present disease models, and the prevalence of disease per retention/restoration status in non-smokers and ex-smokers was assessed further (Figs. 1 and 2). No association was found between peri-implantitis and type of retention ($P = 0.168$) or restoration ($P = 0.175$) when adjusting for smoking status. Results were quantitatively similar for peri-implant mucositis.

DISCUSSION

Our results showed that in a German university-treated sample, there is no direct association between either the type of prosthesis retention or the splinting of restorations (single crowns versus splinted restorations) and peri-implant diseases. The ORs (95% CIs) for peri-implantitis in cement-versus

Table 2.
Disease Prevalence on an Implant-Level

	Overall (N = 394)	Retention Type			Restoration Type		
		Cement (n = 256)	Screw (n = 138)	*P**	Single (n = 192)	Splinted (n = 202)	*P**
3-level disease status, n (%)							
Peri-implantitis	22 (5.58)	15 (5.86)	7 (5.07)	0.734	11 (5.73)	11 (5.45)	0.854
Peri-implant mucositis	225 (57.11)	143 (55.86)	82 (59.42)		108 (56.25)	117 (57.92)	
Health	147 (37.31)	98 (38.28)	49 (35.51)		73 (38.02)	74 (36.63)	
2-level disease status, n (%)							
Peri-implant disease	247 (62.69)	158 (61.72)	89 (64.49)	0.742	119 (61.98)	128 (63.37)	0.587
Health	147 (37.31)	98 (38.28)	49 (35.51)		73 (38.02)	74 (36.63)	

* *P* values arise from GEE models to account for intrapatient correlation attributable to multiple implants nested in each patient.

screw-retained and single versus splinted restorations were 1.43 (0.45, 4.60) and 0.62 (0.22, 1.73), respectively (all *P* values >0.32). Results were also non-significant when retention and restoration types were evaluated as risk indicators for peri-implant mucositis or for overall peri-implant disease (peri-implantitis or mucositis).

Our initial, and subsequently refuted, hypothesis that cement-retained restorations may be associated with increased prevalence for peri-implant diseases stemmed from the growing number of cohort studies and case series suggesting association of excess cement with peri-implant mucosal inflammation and peri-implant attachment loss.[6,15,16] In addition to this previously reported association, the reciprocal association also has been reported. Wilson[6] suggested that the removal of subgingival cement results in resolution of inflammation in three of four cases of peri-implant disease. An ostensible review of such evidence may lead to a witch hunt against cement-retained restorations. The extent of the purported deleterious effects of cement retention in clinical reports has ranged from initiation of peri-implant inflammation to implant failure directly attributed to the cementation procedure.[7,17] Nonetheless, two rudimentary components of the problem have been underreported previously: 1) the influence of cement removal methods, and 2) the differing biologic effect of various types of cements.[15]

The use of cement-retained restorations for implant rehabilitation mandates the use of astute diagnostic methods for the timely detection of residual cement,[18] in combination with meticulous cementation techniques to minimize the risk for residual excess cement.[7,19] It is evident that results of the current study do not apply in cases in which the restorative methods have an increased margin of error for retention of excess cement, e.g., positioning of the restorative interface in a deep submucosal position that hinders access. Nevertheless, even when careful and appropriate technique is used for cementation, selection of cement type remains an important component of the therapeutic procedure. In a retrospective study, Korsch and Walther[20] found a remarkably high percentage of implants cemented with methacrylate cement having cement excess (62%) and mucosal inflammation (94% to 100%) compared to a zinc oxide-cemented group. After removal of the methacrylate cement and recementation of the implant crowns with zinc oxide cement, a reduction in BOP of >75% of the cases was observed.[16] These observations are well aligned with in vitro findings that show increased biofilm growth on resin cements compared to zinc oxide cements,

Table 3.

ORs (95% CIs) for Peri-Implantitis/Peri-Implant Mucositis Versus Health

	Retention Type			
	Cement versus Screw	*P**	Single versus Splinted	*P**
Model 1				
3-level definition of disease	OR		OR	
Peri-implantitis	1.43 (0.45, 4.60)	0.552	0.62 (0.22, 1.73)	0.418
Peri-implant mucositis	0.89 (0.53, 1.48)	0.652	0.87 (0.55, 1.37)	0.542
Health	Reference		Reference	
2-level definition of disease				
Disease	0.92 (0.55, 1.52)	0.742	0.88 (0.55, 1.40)	0.587
Health	Reference		Reference	
Model 2				
3-level definition of disease	OR		OR	
Peri-implantitis	1.45 (0.46, 4.53)	0.519	0.61 (0.22, 1.72)	0.390
Peri-implant mucositis	0.90 (0.54, 1.52)	0.697	0.87 (0.55, 1.40)	0.577
Health	Reference		Reference	
2-level definition of disease				
Disease	0.93 (0.55, 1.56)	0.788	0.88 (0.55, 1.42)	0.616
Health	Reference		Reference	
Model 3				
3-level definition of disease	OR		OR	
Peri-implantitis	1.45 (0.47, 4.45)	0.497	0.63 (0.23, 1.76)	0.321
Peri-implant mucositis	0.88 (0.52, 1.51)	0.694	0.87 (0.54, 1.40)	0.506
Health	Reference		Reference	
2-level definition of disease				
Disease	0.91 (0.53, 1.55)	0.785	0.88 (0.55, 1.43)	0.516
Health	Reference		Reference	

The effect of smoking was not found to be significant in any of the models (all *P* values >0.6).
* *P* values rose from generalized GEE models with a logit link function: model 1, crude; model 2, type of retention adjusted for type of restoration; model 3, model 2 and smoking.

which may show an inhibitory effect against bacterial growth.[21]

Another factor that may, at least in part, explain the present findings of no association between cement retention and peri-implant diseases is the positioning and the diameter of the platform of the implants. The location of the restorative interface has been shown previously to predict the presence of remaining cement excesses independent of other factors.[22] Specifically, the placement of the restorative interface deeper than 1 mm beyond the mucosal level increases the risk of cement excess and minimizes clinicians' ability to effectively remove cement excess after cementation. In the present study, the delivery of restorative care in an academic environment either by board-certified prosthodontists or dentists pursuing specialty certification under the direct supervision of board-certified prosthodontists should be taken into account. As mentioned previously, zinc oxide or zinc phosphate cements were used exclusively in the treatment of all cases, and quality assessment for the clinical work was performed to ensure that no residual cement was left, using thorough clinical assessment. Thus, results of this study may not be generalizable to the implant restorations cemented with resin cements. In addition, all cases were treatment planned jointly by specialists in prosthodontics and specialists in surgical implant placement. The treatment planning dictated implant platform diameter selection according to the desired emergence profile and surgical placement of the platform, with care to position the restorative interface either at the level of or no more than 1 mm below the mucosal level according to the protocol of the clinic.

The results of this study are in accordance with the results a long-term split-mouth clinical study that randomly assigned one cement-retained and one screw-retained implant crown per participant.[23,24] After 10 years of follow-up, the researchers found no significant difference in peri-implant tissue stability in terms of either facial keratinized tissue or marginal bone levels (mean 10-year crestal bone loss,

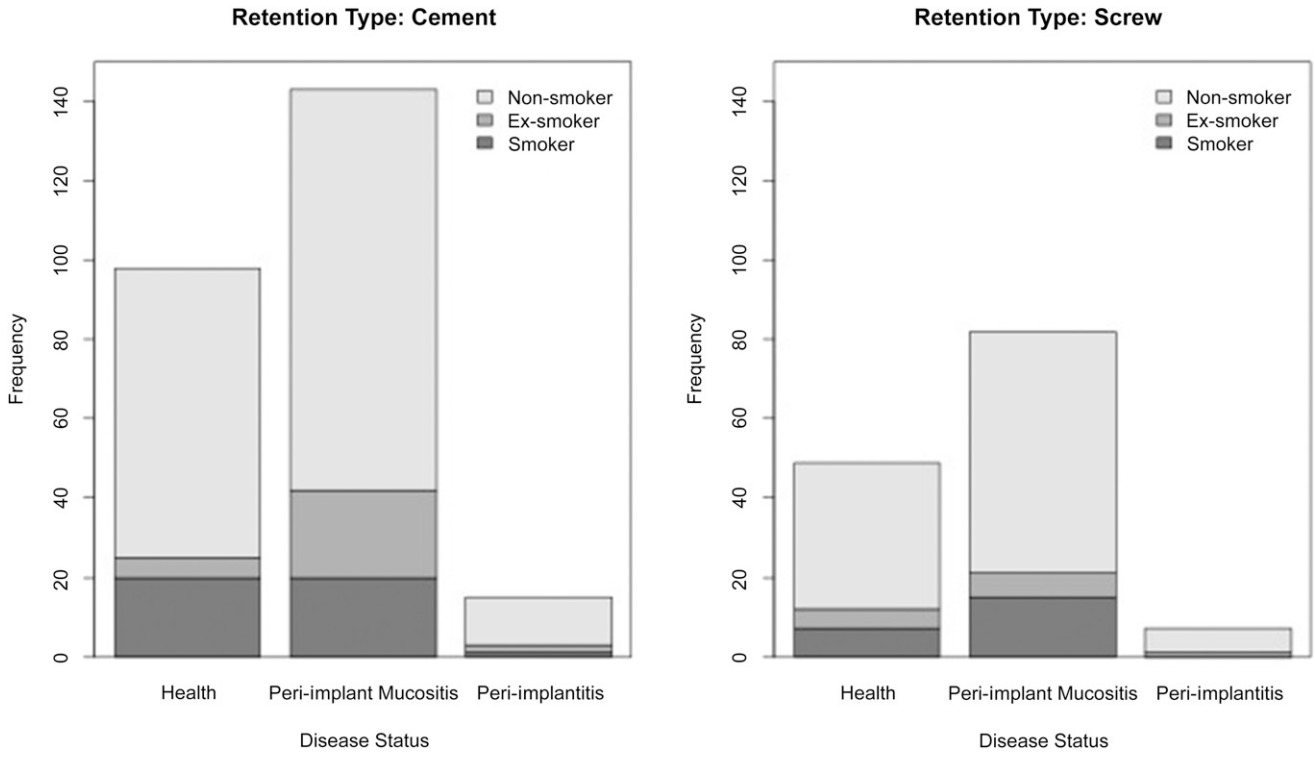

Figure 1.
Bar plot of smoking status by disease type in groups stratified by type of retention. Frequency is displayed on the y-axis.

Figure 2.
Bar plot of smoking status by disease type in groups stratified by type of restoration. Frequency is displayed on the y-axis.

1.1 mm for both groups).[24] In a similarly designed randomized clinical study that followed up participants for 15 years after prostheses delivery, it was also reported that cement retention was not associated with a higher occurrence of peri-implant diseases.[25] Notably, technical complications (e.g., porcelain fracture, abutment screw loosening) and biologic complications (e.g., mucosal inflammation, crestal bone loss) were higher for screw-retained restorations compared to cement-retained ones.[25] The observation of no effect of type of retention on peri-implant health was also confirmed by a recent systematic review that did not find significant differences between the two types of retention.[26] However, in the systematic review, the presence of suppuration was found to be higher for the cemented restorations.[26]

Although none of the available published data show any clear association between cement retention and peri-implantitis compared to screw retention, two clinical studies have reported an increased chance for mucosal inflammation for implants supporting cemented restorations.[16,27] In the study by Korsch and Walther,[20] the association was attributed to residues of a methacrylate cement that were reversed after removal of the crowns and recementation with a zinc oxide cement. In the study by Weber et al.,[27] inadequate information on the type of cement and method of cementation were provided to draw any firm conclusions, so cement excess cannot be excluded in their population.

CONCLUSIONS

This study focuses on important local factors that are modifiable during treatment planning for implant rehabilitation, whereas previous studies have focused mainly on host-related risk indicators for peri-implant diseases. Current findings point out that, when appropriate selection and removal of cement is performed, cement retention is not a risk indicator for peri-implant diseases. The results presented are not supposed to underestimate the issue of the cement excess and its negative effect on peri-implant tissue health, but rather show that by following the appropriate treatment protocol and an evidence-based approach to materials selection, clinicians can limit cement excess and consequently avoid cement-associated biologic complications. In addition, the results should be reviewed cautiously because of the relatively small number of peri-implantitis cases that occurred in the cement-retained group in this study. Collectively, both peri-implantitis and peri-implant mucositis are prevalent in this well-maintained university-treated sample irrespective of the type of retention or restoration. Thus, additional research is warranted to identify modifiable risk indicators of peri-implant disease and aid in the reduction of the incidence of peri-implant diseases.

ACKNOWLEDGMENTS

The authors thank Dr. Robert London (University of Washington, Seattle, Washington) for his critical review of this manuscript and his constructive comments. The authors report no conflicts of interest related to this study.

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Correspondence: Dr. Georgios Kotsakis, 1959 NE Pacific St., Periodontics Box 357444, Seattle, WA 98195. E-mail: kotsakis@uw.edu.

Submitted July 25, 2015; accepted for publication September 21, 2015.