Predictors of Excess Cement and Tissue Response to Fixed Implant-Supported Dentures after Cementation

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ABSTRACT

Background: The cementation of fixed implant-supported restorations involves the risk of excess cement remaining in the peri-implant tissue that may cause a peri-implant tissue response with attachment loss.

Purpose: The aim was to study the peri-implant tissue response after cementation and to detect potential predictors of excess cement.

Material and Methods: Clinical complications after cementation in several index cases led to a recall of all patients treated with a special methacrylate cement (one hundred five patients with one hundred eighty-eight implants) and systematic reevaluation of 71 patients (68%) with one hundred twenty-six implants (67%). In all cases, suprastructures including abutments were removed, and findings were documented.

Results: Implant diameter was significantly associated with the frequency of excess cement. Implant location or system had no significant effect. Excess cement in turn was associated with bleeding on probing, suppuration, and peri-implant attachment loss. In the absence of excess cement 58.8% of implants had no peri-implant attachment loss versus 37.3% when excess cement was present. With increasing retention time of the methacrylate cement, more peri-implant attachment loss was detected. However, the latter association was not significant.

Conclusion: Larger diameters are significantly associated with excess cement in peri-implant tissue. Consequences of excess cement may be increased bleeding on probing, suppuration, and possibly peri-implant attachment loss.

KEY WORDS: cement-retained dentures, excess cement, implants, peri-implantitis

INTRODUCTION

When prosthetic restorations are cemented on implants, excess cement may penetrate into the surrounding structures. In general, such cement is removed after cementation. However, a cement film of varying thickness may remain in the peri-implant sulcus. The consequences may be peri-mucositis, peri-implantitis, or even the loss of the implant.[1–3] There are few clinical studies dealing with this subject,[2] only some case reports describing the consequences of excess cement left in the tissue.[1,3–5] In a follow-up examination of patients with cement-retained implant-supported restorations, Wilson found residual cement around 81% of the implants with sulcular bleeding and/or suppuration. Four weeks after removal of the residual cement, no signs of inflammation were detectable any more in 75.7% of the cases.[2] Bacterial colonization of the cement in the peri-implant tissue can be considered the most important cause of inflammation associated with excess cement. This applies particularly when methacrylate-containing cements are used. Other dental materials are also more or less prone to biofilm formation[6] and thus are a hazard in the peri-implant sulcus.

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The risk of leaving excess cement may depend on the amount of cement used and the procedure of cementation. Some publications recommend a clinical cementation protocol to minimize the risk.[5,7–9] However, there is no evidence that such protocols have a favorable effect on implant survival time. The properties of the cements used are supposed to be additional risk factors, especially viscosity. Low-viscosity cements are assumed to spread more easily in the peri-implant sulcus than high-viscosity materials, although the clinical proof of this assumption has yet to be furnished. What has been proved, however, is a relation between the submarginal level of the implant-supported restoration and excess cement. Submarginal restorations with deep margins show significantly more excess cement than implant-supported restorations placed at a shallow submarginal level.[10,11] This is thought to be due to the far greater difficulty to remove the excess cement under the clinical conditions of deeply located restoration margins. Hence, if deep submarginal restorations cannot be avoided, screw-retained connection should be preferred.

From April 2009 until February 2010, a temporary two-component methacrylate cement (Premier Implant Cement, Premier® Dental Products Company, Plymouth Meeting, PA, USA) was used by the Dental Academy for Continuing Professional Development, Karlsruhe, Germany, for cementing fixed dental restorations on implants. After some weeks or months, peri-implant inflammation with the clinical signs of bleeding and suppuration was observed in some cases. In all these cases, residual cement was found. After its removal, the signs of inflammation disappeared within a period of 3 to 4 weeks. As a consequence, all patients who had been treated with this type of cement were reinvited for clinical revision. Prosthetic structures and abutments were taken out to ensure that excess cement was completely removed.

The present clinical cohort study investigates the influence of excess cement on peri-implant tissue and peri-implant attachment.

MATERIAL AND METHODS

In the period from April 2009 to February 2010, fixed implant-supported restorations were inserted in one hundred five patients by 10 prosthodontists of the Karlsruhe Dental Academy for Continuing Professional Development.

All implants were placed by the same oral surgeon. There were different types of surgeries with and without bone graft in one or two stages. The implants healed trans- or submucosally. If a reopening of an implant was necessary, the prosthodontic therapy started 4 weeks later.

The loading protocol for all fixed dentures was delayed 3 to 4 months after implantation. In all cases, a methacrylate cement was used (Premier Implant Cement, Premier Dental Products Company). Restorations were placed on a total of one hundted eighty-eight implants in one hundted five patients. Although the handling instructions of the cement manufacturer and a standardized cementation protocol were followed and all residual cement was completely removed in the view of the dentist, in some cases complications developed after a few weeks or months. The clinical findings were bleeding and suppuration from the peri-implant tissue. When the abutments were taken out; excess cement was found in all these index cases. After the cement had been removed, the signs of inflammation disappeared within a few weeks. The clinic stopped using the cement mentioned in March 2010.

Study Population

All patients whose implant-supported crowns were cemented with the cement mentioned above were contacted by telephone and asked to present again. From April to November 2010, the restorations on one hundted twenty-six implants in 71 of the one hundted five patients were retreated. Revisions after that time were not included in the documentation.

Thirty-seven of the 71 patients were women (69 implants) and 34 were men (57 implants). The patients' average age was 60.7 years with a range of 32 to 81 years. The implant-supported restorations consisted of single crowns and multiple-unit bridges. The number of implants per patient was between one and five.

Documentation and Revision – Clinical Procedure

One prosthodontist left the academy prior to revision therapy. The remaining nine prosthodontists examined and restored between two and 39 implants (Figure 1). Each restorative dentist examined and retreated the implant-supported restorations he/she had placed:

- Before removing the suprastructure, the peri-implant tissue was explored with a probe at six sites

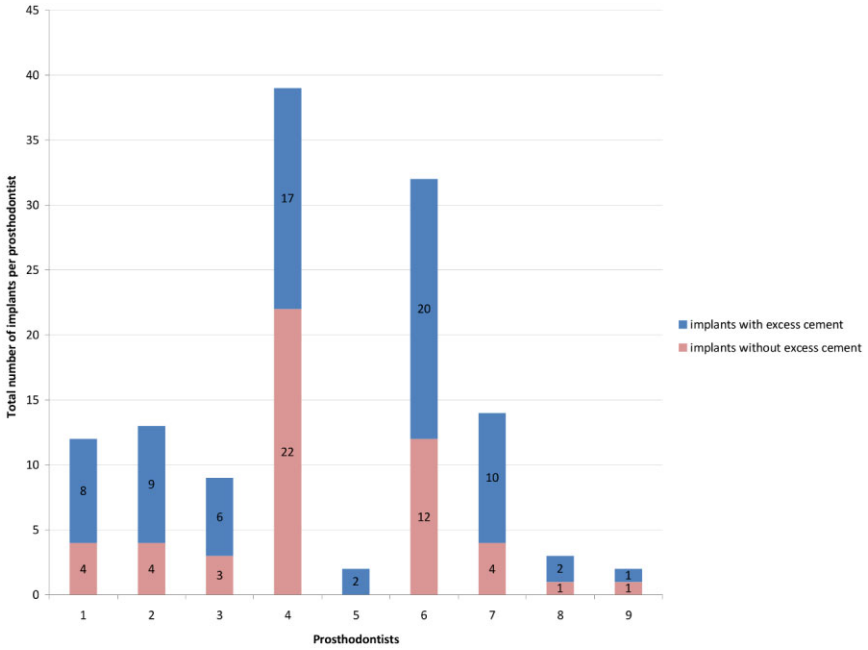

Figure 1 Frequency of excess cement by attending prosthodontist (n.s.).

per implant. Presence or absence of bleeding on probing and pocket suppuration were documented.

- Then the suprastructures and the abutments were taken out with forceps or a hook.
- After removal, the presence or absence of cement in the peri-implant tissue was documented.
- Residual cement was removed from the crown and abutment, and the peri-implant tissue was rinsed with chlorhexidine 0.12% (GUM® PAROEX® nonalcohol rinse 0.12%, Sunstar Suisse S.A., Etoy, Switzerland).
- After that, the bone level in relation to the implant shoulder was determined in millimeters. With a periodontal probe, the distance from the implant shoulder was measured at four sites around each implant, see below.
- Based on the medical records, the implant type and diameter as well as the implant location were documented.
- Finally, chlorhexidine gel 0.2% was filled into the hollow implant. The abutments were reinserted, and the suprastructures were recemented with Temp Bond (Temp Bond, Kerr Sybron Dental Specialties, Glendora, CA, USA).

Peri-Implant Attachment Loss

The attachment level represents the distance between the implant shoulder and the measuring point in the depth of the peri-implant tissue. During every approval of an implant for prosthodontic therapy, the attachment level was measured, and an X-ray was done. The attachment level was determined with a periodontal probe at four measuring points around each implant. Every attachment level with 1 mm or more was documented with its location. If the attachment level was more than 2 mm, it was tried to improve the situation with further surgical therapy.

During revision therapy, the attachment level was measured in the same way. The attachment loss was the difference of attachment level at implant approval and at revision therapy. The biggest of the four values measured was documented. It corresponds to the biggest peri-implant attachment loss. Follow-up X-rays were not made in accordance to the German radiation protection standards. For analysis, attachment loss was divided into two groups:

Group 1: no peri-implant attachment loss; and
Group 2: peri-implant attachment loss of 1 mm or more.

Implant Type

In the period mentioned, three implant systems were used (Astra OsseoSpeed™, Astra Tech Dental, Mölndal, Sweden; CAMLOG® SCREW-LINE Promote® plus, ALTATEC GmbH, Wimsheim, Germany, and SKY

classic, Bredent medical GmbH & Co.KG, Senden, Germany). In all, 53 Astra, 52 Camlog, and 21 SKY implants were involved.

Implant Diameter

The documented diameters of the one hundred twenty-six implants involved were:

Astra OsseoSpeed: 3.5 mm, 4.0 mm, 4.5 mm, and 5.0 mm;
CAMLOG SCREW-LINE Promote plus: 3.3 mm, 3.8 mm, 4.3 mm, 5.0 mm, and 6.0 mm; and
SKY classic: 3.5 mm, 4.0 mm, and 4.5 mm.

For statistical analysis, the diameters of the three implant systems were subdivided into:

Group 1: diameter 3.3 to 3.8 mm (31 implants);
Group 2: diameter 4.0 to 4.3 mm (44 implants); and
Group 3: diameter 4.5 to 6.0 mm (51 implants).

Implant Locations

The locations of the implants were also subdivided into three groups:

Group 1: maxillary and mandibular incisors and canines (16 implants);
Group 2: maxillary and mandibular premolars (39 implants); and
Group 3: maxillary and mandibular molars (71 implants).

Statistical Methods

The data were compiled with Excel and analyzed with IBM SPSS Statistics 21 (SPSS Inc., Chicago, IL, USA) on Windows XP. Statistical methods used were cross-tabulation with chi-squared tests for categorical data. The association between grouped implant diameter (ordinal scale) and cement was analyzed by means of the test for trend with one degree of freedom. Variance analysis was used for comparisons of cement dwelling times. Multivariate associations with binary dependent variables were analyzed using multiple logistic regressions. Nagelkerke's pseudo-R-squared is given to indicate the strength of the association.

Dropout Analysis

Thirty-four patients did not show up for revision (32 %) (Table 1). Sixty-two implants (33%) were lost to follow-up. Dropout analysis showed no significant differences in the attending prosthodontist, implant location, implant system, or implant diameter between dropouts and nondropouts.

TABLE 1 Total Number of Restored Implants Per Prosthodontist by Nondropouts and Dropouts; Prosthodontist Number 10 Left the Clinic Prior to Revision Therapy

Prosthodontist	Nondropout	Dropout	Total Number of Implants with Restorations
1	12	6	18
2	13	11	24
3	9	2	11
4	39	5	44
5	2	5	7
6	32	21	53
7	14	5	19
8	3	0	3
9	2	0	2
10	0	7	7
Total	126	62	188

RESULTS

Altogether one hundred twenty-six implants were examined in 71 patients. The time interval between cementation of the crown and reevaluation was within a range of 116 to 640 days with an average interval of 261 days (median 234, standard deviation 100 days).

Predictors of Excess Cement

Excess cement was documented around 75 implants (59.5%). The presence of excess cement was significantly associated with the diameter of the implant (larger diameter implants having more often excess cement) (Figure 2). There was no significant association between excess cement and implant location or implant system. Though cementation is a prosthodontic manual procedure, there was no significant association between the frequency of excess cement and the attending prosthodontist (Figure 1).

Bleeding on Probing

Sixty-nine of the one hundred twenty-six implants (54.8%) bled on probing. Excess cement (Table 2), implant diameter, and implant location each demonstrated a significant association with bleeding on

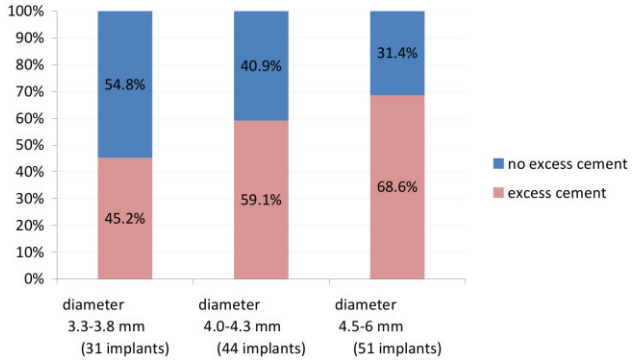

Figure 2 Cement by grouped implant diameter (test for trend, $p = .038$).

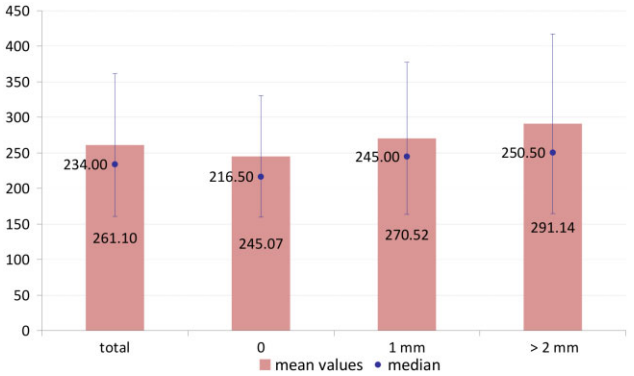

Figure 3 Association of peri-implant attachment loss and the methacrylate cement residence time in days (n.s.).

probing, but the implant system and the residence time of the cement until revision did not.

In a logistic regression with bleeding on probing as dependent variable, the presence of cement was by far the most important predictor of bleeding on probing (Table 3). The implant diameter lost its significance when it was analyzed in connection with the presence of excess cement.

Suppuration

Sixteen implants demonstrated suppuration. All of them also bled on probing and had excess cement (Table 4). So detailed analysis had to be waived due to collinearity.

Peri-Implant Attachment Loss

No peri-implant attachment loss was found around 58 of the one hundred twenty-six implants (46%). Fifty-four showed a 1 mm loss in attachment level, 14 a loss of 2 mm or more. Increasing attachment loss was associated with an increasing residence time of the methacrylate cement until revision (Figure 3). This trend, however, was not significant in variance analysis.

Bivariate analysis showed significant associations between attachment loss on the one hand and excess cement on the other (Figure 4), bleeding on probing on the one hand and suppuration on the other, but there were no significant associations with implant location, patient gender or implant system.

If in a logistic regression implant diameter and implant location are considered in addition to the presence of cement, the variable of "cement present" increases in significance. The presence of excess cement raises the odds of attachment loss by 2.3 (95% confidence interval 1.1–4.9) compared with the absence of excess cement. Implant location and diameter are no significant predictors of bone loss in multivariate analysis either.

If, however, the intervening variable bleeding on probing is included in the logistic estimator equation for attachment loss, excess cement is far less associated with attachment loss (odds ratio now 1.3) and bleeding

TABLE 2 Association between Bleeding on Probing (BOP) and Excess Cement

		Excess Cement Present		
		No	Yes	Total
BOP present	No	42	15	57
	Yes	9	60	69
Total		51	75	126

Chi-squared 47.6 ($p < .001$).

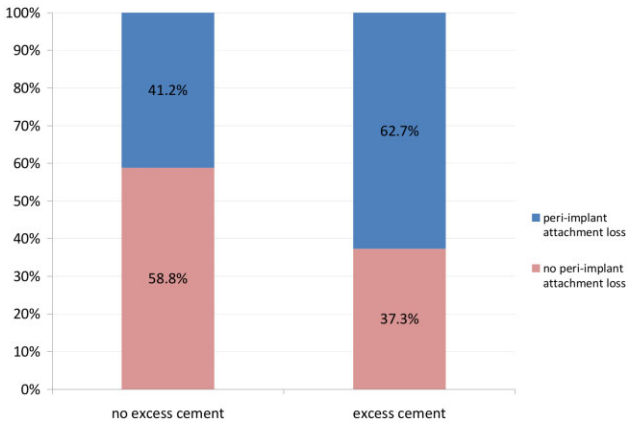

Figure 4 Peri-implant attachment loss by cement (Chi-square 5,643; $p = .018$: significant association between excess cement and peri-implant attachment loss).

TABLE 3 Association between the Dependent Variable of Bleeding on Probing and Excess Cement, Implant Diameter, and Implant Location

	Regression Coefficient B	Standard Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for EXP(B)	
							Lower Value	Upper Value
Cement present	2.936	0.494	35.309	1	0.000	18.844	7.154	49.633
Diameter			3.286	2	0.193			
Diameter 4–4.3 mm	1.153	0.656	3.093	1	0.079	3.169	0.876	11.461
Diameter 4.5–6 mm	1.049	0.714	2.155	1	0.142	2.854	0.704	11.573
Implant location			2.947	2	0.229			
Implant location 2	–1.393	0.858	2.639	1	0.104	0.248	0.046	1.334
Implant location 3	–0.768	0.879	0.763	1	0.382	0.464	0.083	2.599
Constant	–1.497	0.836	3.204	1	0.073	0.224		

Nagelkerkes R-squared 0.50.

on probing now becomes the strongest predictor of attachment loss (odds ratio 2.9, 95% confidence interval 1.1–7.5) (Table 5).

DISCUSSION

There are no reliable estimates of the prevalence of excess cement around fixed implant-supported restorations. The patient population examined for this study was systematically recalled after the occurrence of index cases in patients treated with a particular methacrylate cement. Despite invitation, only 71 of one hundred five eligible patients appeared for revision in the period from April to November 2010. This illustrates how difficult it is to follow up a defined patient cohort completely. Dropout analysis did not show appreciable differences between patients lost to follow-up and those reinvestigated. For this reason, clinical systems without any inherent risks should be used as far as possible.

Upon reevaluation, excess cement was found around 59.5% of the implants. This proportion appears to be unusually high and may possibly be explained by the material characteristics of the cement used in these patients. Evidently other predictors also have an influence on the presence of excess cement. So far, only the submarginal position of fixed implant-supported restorations has been reliably established as a predictor. Restorations with deep submarginal levels demonstrate significantly more excess cement than implant-supported restorations with more shallow submarginal levels.[10,11] As a consequence, whenever esthetic considerations are unimportant, the abutment shoulder should be placed epimarginally. If deep submarginal restorations cannot be avoided, a screw-retained connection should be preferred. The amount of cement used and the cementation protocol are supposed to be predictors of excess cement.[5,7,8,12] However, there is no clinical demonstration.

TABLE 4 Association between Suppuration and Excess Cement

		Cement Present		
		No	Yes	Total
Pus present	No	51	59	110
	Yes	0	16	16
Total		51	75	126

Chi-squared 12.5 ($p < .001$).

Predictors of Excess Cement

In this study, a significant effect of the implant diameter on excess cement in the peri-implant tissue could be established. With increasing implant diameter, excess cement was found with increasing frequency. Hence, implants with smaller diameter would have to be preferred for fixed cement-retained suprastructures. The implant diameter, however, is not only associated with excess cement, but also has static properties. Implants of smaller diameter have a stronger tendency toward material fatigue. The consequence may be abutment and implant fracture.[13,14] Therefore, the critical diameter at which disadvantages outweigh benefits has yet to be determined by future research. There was no significant association between the frequency of excess cement and

TABLE 5 Association between the Dependent Variable of Attachment Loss (No Loss vs Loss of 1 mm or More) and Cement, Implant Diameter, Implant Location, and Bleeding on Probing

	Regression Coefficient B	Standard Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for EXP(B)	
							Lower Value	Upper Value
Cement present	0.237	0.480	0.244	1	0.621	1.268	0.495	3.246
Diameter			2.885	2	0.236			
Diameter 4–4.3 mm	–.754	0.543	1.929	1	0.165	0.470	0.162	1.364
Diameter 4.5–6 mm	–.119	0.603	0.039	1	0.844	0.888	0.272	2.895
Implant location			1.134	2	0.567			
Implant location 2	–.698	0.663	1.110	1	0.292	0.497	0.136	1.823
Implant location 3	–.580	0.670	0.749	1	0.387	0.560	0.150	2.083
Bleeding on probing	1.058	0.490	4.663	1	0.031	2.881	1.103	7.528
Constant	0.310	0.669	0.215	1	0.643	1.363		

Nagelkerkes R-squared 0.144.

the attending prosthodontist. The number of restored implants provided by the respective prosthodontists ranged between two and 39. Thus, further investigations on provider variability are recommended.

Implant location and implant system had no direct significant association with excess cement.

Bleeding on Probing/Suppuration

Inflammation around implants may have many different causes.[2,15,16] In the literature, the incidence of peri-implantitis is stated to be 1.8% to 10% after a period of 5 to 10 years.[15,17,18] Within the first 3 to 5 years, about 20% to 25% of the cases develop peri-mucositis or peri-implantitis.[19,20] Against this background, the bleeding on probing score of 54.8% of the implants within 1 to 2 years found in the present study appears to be very high. The strongest predictor of bleeding on probing was excess cement. The 80% of the implants with residual cement left in the peri-implant tissue demonstrated bleeding on probing. Wilson arrived at roughly the same results.[2] Other significant predictors identified in our study were implant diameter and implant localization. The implant system, cement residence time until revision, and the patient's gender did not show any significant association with bleeding on probing. Suppuration was diagnosed around 12.7% of the implants. Each of these affected implants also demonstrated bleeding on probing. In all cases, excess cement was found. For comparison, Buser and colleagues reported suppuration in 0.4% of five hundred eleven implant cases after 10 years.[18] The association between larger implant diameters and bleeding on probing, however, is essentially mediated by the presence of cement, as multivariate analysis shows.

Attachment Loss

Strictly speaking, the bone loss around an implant cannot be determined by peri-implant probing. The peri-implant tissue between the probe and the bone prevents exact measuring and thus underestimates the true bone loss. Often the peri-implant bone level is evaluated radiographically.[21,22] As our survey is not an experimental trial, but an observational study with a starting point in the past, follow-up X-rays for measurement purposes only were not done in accordance with German radiation protection regulation.

Forty-six percent of the implants did not show any attachment loss in the period under review, whereas 42.9% of the implants had an attachment loss of 1 mm and 11.1% of 2 mm or more. Renvert and colleagues defined peri-implantitis as peri-implant bone loss of ≥1 mm after 1 year and bleeding on probing and/or suppuration.[23] According to this definition, 36.5% of the implants in the present study would demonstrate peri-implantitis after 1 to 2 years. In the literature, the peri-implant bone loss within the first year is stated to be 0.35 to 2 mm.[24,25]

Significantly associated with the peri-implant attachment level were excess cement, bleeding on probing, and suppuration. After considering implant diameter and implant location, excess cement had an even greater influence as a significant predictor of bone loss. Mumcu and colleagues did not find any influence of the implant diameter on the bone level.[26] There is a

controversial discussion about the association between implant system and peri-implant bone level.[23,25] In the present study, no significant influence of the implant systems on the attachment level could be detected.

The presence of excess cement increases the odds of attachment loss by 2.3 (95% confidence interval 1.1–4.9) versus the absence of excess cement. So far, no other studies have been made on this subject. There only are some case reports describing peri-implant bone loss due to residual cement.[3,4,7] An increasing residence period of the methacrylate cement in situ up to the time of revision was connected with increasing attachment loss. This tendency, however, was not significant in variance analysis.

Excess cement was the most powerful predictor of bleeding on probing and suppuration. On a multivariate basis (taking implant location and diameter into account), it also was a significant predictor of attachment loss. However, if bleeding on probing is additionally considered in connection with attachment loss, bleeding on probing is the most important predictor of peri-implant attachment loss. Bleeding on probing as a primary clinical inflammation marker thus prevails statistically against excess cement as a variable that is more remote from the process of attachment loss.

In multivariate logistic regression, the patient's gender together with excess cement was not significant, neither for the dependent variable of bleeding on probing nor for the dependent variable attachment loss.

CONCLUSION

In all, our data fully agree with the causal chain of implant diameter → excess cement → peri-implantitis → attachment loss.

Larger implant diameters are significantly associated with the presence of excess cement in the peri-implant tissue. The consequences of retained excess cement can be increased bleeding on probing, suppuration, and peri-implant attachment loss. Therefore, excess cement should be avoided whenever possible. A critical implant diameter has yet to be determined more precisely.

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