

# Minimizing Excess Cement in Implant-Supported Fixed Restorations Using an Extraoral Replica Technique: A Prospective 1-Year Study

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**Purpose:** Cementation of implant-supported restorations poses two major challenges: (1) minimizing excess cement (reducing the risk of peri-implantitis), and (2) establishing sufficient retention (reducing the risk of decementation). This study presents the first data on a clinical cementation technique that might address both problems. **Materials and Methods:** Between 2011 and 2013, 39 patients were provided with 52 implants supporting 52 single crowns (SCs). All restorations were cemented extraorally using replicas made of pattern resin and zinc oxide cement. All decementation events and the peri-implant soft tissue status were assessed and compared with those from a group of 29 patients with 40 conventionally cemented SCs (control). **Results:** In the experimental group, after 12 months, decementation was recorded in three individuals (7.69%) with 3 SCs (5.77%). In the control group, after 12 months, no case of decementation was recorded. No cases of peri-implantitis were detected in either group. **Conclusion:** Within the limitations of this study, the authors conclude that the use of zinc oxide cement initially establishes sufficient retention of implant-supported fixed restorations independent of conventional or replica cementation techniques. INT J ORAL MAXILLOFAC IMPLANTS 2015;30:1355–1361. doi: 10.11607/jomi.3967

**Key words:** decementation, dental implant, excess cement, single crowns, zinc oxide–noneugenol cement

Fixed dentures borne by implants are mostly retained using screws or a cement material. Both techniques confer different advantages and disadvantages.

Screw-retained restorations can be removed relatively easily whenever it becomes necessary (ie, when caused by abutment loosening, for maintenance procedures, or if the veneering ceramic is chipped) and to achieve superior marginal precision.<sup>1</sup> In cases of limited interarch space, screw-retained restorations might be indicated because of a small abutment height

causing an insufficient retention area for luting agents. In contrast, reduced esthetics resulting from the screw access channel; the risks of loosening, restoration fracture, or accidental aspiration of the screw; and elevated laboratory costs may be considered as disadvantages. Furthermore, gaining access to screw channels may be difficult in posterior regions or in cases of lingual screw placement.

Chee et al<sup>2</sup> failed to demonstrate the superiority of screw-retained over cemented restorations for clinical use. However, a recent study found cemented crowns to be superior to screw-retained crowns in biological and technical aspects.<sup>3</sup> A recent systematic review and meta-analysis comparing cemented and screw-retained prostheses did not reveal any difference in peri-implant marginal bone loss.<sup>4</sup>

Cemented crowns provide better accessibility, especially in posterior areas, and exhibit inferior porcelain fracture rates compared with screw-retained crowns.<sup>5,6</sup> Cementation also offers considerably reduced laboratory costs and superior esthetic outcomes.<sup>7</sup> Furthermore, cemented crowns have shown lower rates of peri-implant disease<sup>3,8</sup> compared with screw-retained crowns. However, in patients with a history of periodontitis, cemented restorations have been reported to cause a higher incidence of peri-implant disease compared with screw-retained restorations.<sup>9</sup>

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A wide range of cement types have been proposed to lute fixed restorations on implant abutments (eg, zinc oxide cements with or without eugenol, zinc phosphate cement, glass ionomer cement, polycarboxylate cement, and resin cement); these cements provide different grades of retentive force ranging between 177 N (eugenol-free zinc oxide cement) and 813 N (polycarboxylate cement).<sup>10</sup>

When using the cementation technique, excess cement may be compressed between the implant-abutment surface and peri-implant soft tissues. In many cases of implant-supported restorations, the presence of deep subgingival crown margins is inevitable because of implant system components and local anatomy. There is a direct relationship between the subgingival depth of crown margins and the ability of clinicians to completely remove excess cement.<sup>11</sup> Clinical studies have indicated that excess cement is strongly associated with peri-implant disease<sup>8,9,12-14</sup> and even implant loss.<sup>15</sup> To overcome this problem, it has been proposed that preparation for cementation first be performed extraorally using implant analogues,<sup>16</sup> chairside-fabricated silicon analogues,<sup>17</sup> or abutment analogues placed on the laboratory model.<sup>18</sup> Furthermore, a venting technique has been described to avoid excess cement.<sup>19</sup>

Finally, clinicians face two major challenges in cementation: minimizing excess cement (cementation technique) and balancing retentive forces (choice of cement type).

With little clinical data currently available, the adverse effects of excess cement may have been underestimated. This study presents a clinical technique for the cementation of implant-supported fixed restorations that addresses the major problems by using an extraoral cementation technique together with low-retention cement (zinc oxide cement) in a private practice setting. A clinical comparison was made of the extraoral replica technique with the traditional cementation technique. Because the replica cementation technique leaves only a very thin layer of cement inside the crown, this study was conducted to assess whether sufficient retention can be established—at least in the first period of intraoral service—using zinc oxide cement as the luting agent.

## MATERIALS AND METHODS

This prospective clinical study was conducted in a dental office specializing in implant therapy (Northern Hessa Implant Center, Hofgeismar, Germany). The study was based on the analysis of primary patient data and evaluated the clinical outcomes of implant-supported fixed restorations retained using zinc oxide

cement. The study was reviewed and authorized by the Ethics Commission of the Albert-Ludwigs University Freiburg, Germany (application no. 46/10-120329). The recommendations for strengthening the reporting of observational studies in epidemiology (STROBE) were followed.<sup>20</sup>

### Study Population

Patients who were provided with implant-supported single crowns in the period between September 2009 and February 2013 were identified. These patients were approached during their final appointments for the intraoral delivery of prostheses and asked to participate in the study. They received written information about the aims and course of the study. Patients who gave written informed consent and met the following inclusion criteria were included:

- Age 18 years or older
- Received surgical and prosthetic treatment in the study center
- Had restorations manufactured using the metal-ceramic technique
- Underwent retention of the restoration via zinc oxide cement using the replica technique
- Experienced a functional period of the final restoration of more than 12 months

The following exclusion criteria were applied:

- Full ceramic restorations
- Crowns without a subgingival margin depth of 1.5 mm or more in at least 50% of instances
- Use of prefabricated abutments that were not transferred to the dental laboratory

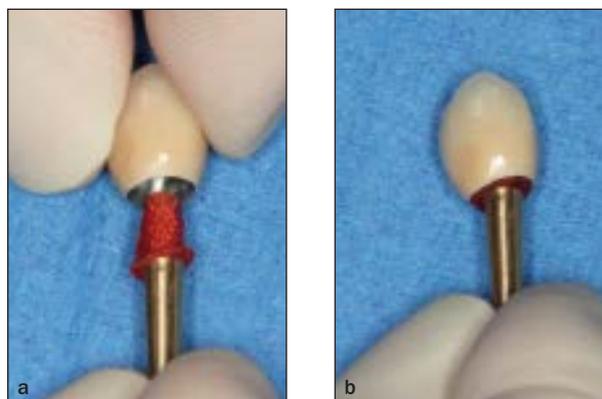
### Course of Treatment

Surgical treatment was performed under local anesthesia, following the implant manufacturer's protocol. All clinical procedures were performed by the same experienced clinician (E.F.). Antibiotics were administered 1 hour before and continued for 1 week after the surgery (amoxicillin, 1,000 mg 3 times per day). Wounds were assessed after 7 days (suture removal) and 28 days. Implant-uncovering surgery was performed after 3 months. The prostheses were fabricated according to the manufacturer's guidelines. Because the patients did not wish their crown margins to be visible, a subgingival vestibular crown margin depth of 1.5 mm was usually attempted. According to the findings of Wolfart et al,<sup>10</sup> the dental laboratory was advised not to sandblast the surface of the implant abutments. In all cases, the dental laboratory was provided with the original abutments meant for subsequent intraoral use at a later date to achieve maximal precision of the final restoration.

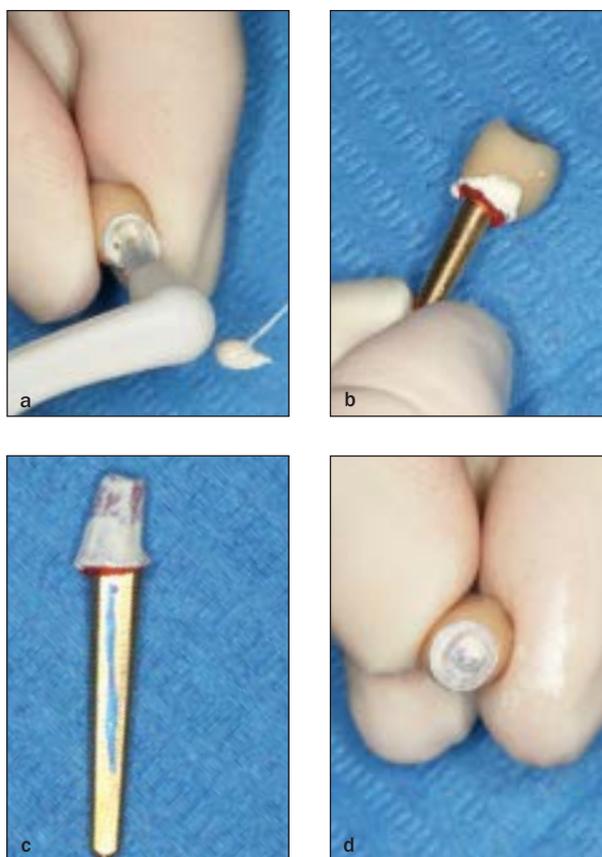
For cementation of the restorations, eugenol-free zinc oxide cement was prepared (Temp Bond, Kerr Sybron Dental Specialties), and a replica of the internal side of the crown (pattern resin with a model pin as shown in Fig 1) was fabricated by the dental laboratory. To create the replica, the intaglio surface of the crown was first coated with petroleum jelly. Then, pattern resin was mixed and filled into the crown, and a model pin was inserted. After the pattern resin had completely polymerized, the replica was removed. Finally, the implant abutment, the intaglio surface of the crown, and the replica were cleaned and degreased using superheated steam and acetone. After removal of the healing abutment, the definitive abutment was fixed on the implant with screws. The access holes of the screws were sealed with soft wax, and the abutment was dried using an air syringe. Then the cement was mixed and filled in the internal side of the crown using a small brush (Fig 2a). The replica was then inserted, and the excess cement was pressed out (Fig 2b) and removed using synthetic pellets (Pluradent). After withdrawal of the replica (Fig 2c), the crown was ready for intraoral cementation (Fig 2d) and could be attached to the implant abutment (Fig 3). If all components and equipment are prepared accurately, there usually is enough time to place the restorations intraorally. After the intraoral cementation of the crown, only a dental probe was used for cement removal; no additional methods (ie, scaler, dental floss) were used. Finally, a radiograph was taken using the long cone technique. Throughout the entire study period, prosthesis design, material selection, and technical procedures remained unchanged. After delivery of the restorations, oral hygiene instructions were given to all patients. Subsequently, the patients were scheduled for a supportive postimplant hygiene therapy program with a 3-month recall. These sessions included evaluating the peri-implant tissue status using the Quigley-Hein plaque index,<sup>21</sup> measuring the probing pocket depth (PPD) using a millimeter-scaled periodontal probe (PCP 15, Hu-Friedy) at four locations per implant (mesiobuccal, distobuccal, mesio-oral, disto-oral) and noting any bleeding on probing (BOP) 30 seconds after probing. In addition, signs of peri-implant inflammation (tissue swelling, suppuration) were assessed by an experienced periodontist.

### Data Collection

Between January 1, 2012, and June 1, 2013, using patient records, the patients in this study were evaluated according to the following parameters: age and sex, anatomic position of the implants, number of implants, loss of implants, time of intraoral delivery, opposing dentition, period of observation, and technical complications involving implants and restorations, such as decementation, abutment loosening, or material

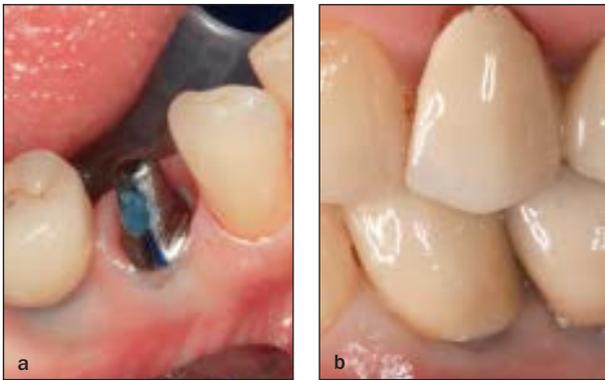


**Figs 1a and 1b** Abutment analogue for extraoral cementation fabricated from pattern resin and a model pin.



**Figs 2a to 2d** (a) Application of zinc oxide cement with a small brush; (b) excess cement after insertion of the replica; (c) withdrawn replica; and (d) view of intaglio surface of the crown after the removal of excess cement, ready for intraoral cementation.

fractures. An external investigator examined the radiographs taken after cementation to detect excess cement. All measurements were performed digitally using the SIDEXIS program (Sirona Dental Systems).



**Figs 3a and 3b** Intraoral view of individualized implant abutment (screw access channel closed with wax) and definitively cemented metal-ceramic crown.

**Table 1 Patient (n = 39) and Implant (n = 52) Characteristics**

Mean age ± SD (y)	53.17 ± 13.98
Sex, No. (%)	
Female	28 (72)
Male	11 (28)
General illnesses, No. (%)	
Diabetes mellitus	2 (5)
Coronary heart disease	10 (26)
Active smoker, No. (%)	5 (13)
Opposing dentition, No. (%)	
Fixed	50 (96)
Removable denture	2 (4)
Mean implant length ± SD (range), mm	10.80 ± 1.23 (8 – 14)

SD = standard deviation.

**Table 2 Anatomical Distribution of Implants According to the FDI Scheme**

No. of implants in maxilla (n = 30)	0	1	2	2	2	1	3	1	2	5	3	2	3	3	0	0
Tooth position (FDI)	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
No. of implants in mandible (n = 22)	0	2	4	1	0	0	0	0	1	0	0	1	3	8	2	0

FDI = Fédération Dentaire Internationale.

**Diagnostic Criteria and Statistical Analysis**

Any technical complications related to the restoration or the implant abutment (eg, abutment screw loosening, fracture of abutment, fracture of the veneering ceramic) were recorded. After agreeing to participate in the study, the patients were clinically examined by an experienced dentist (E.F.), who evaluated the biological and technical complications related to the implants and restorations. Every recorded incident of BOP was defined as peri-implant mucositis.<sup>22</sup> Because of the small sample size, a meaningful statistical analysis of potential factors influencing the outcome of the treatment was not possible. Therefore, only descriptive statistics were applied.

**RESULTS**

Three patients with four implants were noncompliant with the supportive postimplant hygiene therapy program. They did not attend any visits after delivery of the intraoral prostheses and were therefore excluded from the analysis (dropout rate, 7.69%). Telephone calls were conducted to evaluate the reasons for their lack of follow-up. Two patients changed their dental provider and one patient could not be reached.

**Experimental Group**

A total of 39 patients with 52 implants supporting single crowns were included in this study. The patients' pertinent data are provided in Table 1; Table 2 provides data on the anatomic distribution of the implants. During the observation period of 12 months, three implants (5.77%) in three individuals (7.69%) underwent decementation (Table 3). No implants were lost (100% survival rate). No further technical complications were recorded. Therefore, during the first year of intraoral service, the success rate of the cementation procedure was 94.23% for single crowns. No excess cement was detected on the radiographs. No cases of peri-implant suppuration or mucosal swelling were recorded, nor were any elevated PPD scores noted (mean PPD/implant = 3.43 ± 0.63 mm; median = 3.50; range = 2–5 mm). Peri-implant mucositis was diagnosed in 16 implants (30.77%) of 13 individuals (33.33%). Table 3 provides the data on the status of the peri-implant tissues.

**Control Group**

A total of 29 patients with 40 single crowns affixed to implants using zinc oxide cement using the conventional cementation technique served as the control subjects. After more than 12 months, no case of

**Table 3 Decementation Rates and Peri-Implant Tissue Assessment of Patients (n = 39) and Controls (n = 29) After 12 Months**

	Implants investigated (replica technique) (n = 52)		Implants control (conventional cementation) (n = 40)	
	No.	%	No.	%
Decementation (individuals)	3	7.69	0	–
Decementation (implants)	3	5.77	0	–
Tissue swelling	0	0	0	0
Suppuration	0	0	0	0
BOP+ (mucositis) implants	16	30	9	22.05
BOP+ (mucositis) patients	13	33.33	8	27.59
Mean PPD (range) (mm)	3.43 ± 0.63 (2–5)		3.70 ± 0.76 (2–6)	
Peri-implantitis	0	0	0	0

BOP = bleeding on probing; PPD = probing pocket depth; SD = standard deviation.

accidental decementation was noted. No implants were lost (100% survival rate). No further technical complications were recorded. Therefore, during the first year of intraoral service, the success rate of the conventional cementation procedure was 100% in single crowns. No excess cement was detected on radiographs. No cases of peri-implant suppuration or mucosal swelling were recorded. No elevated PPD scores were noted (mean ± standard deviation PPD/implant = 3.70 ± 0.76 mm; median = 3.50; range = 3–6 mm). Peri-implant mucositis was diagnosed in nine implants (22.05%) of eight individuals (27.59%).

## DISCUSSION

The goals of this study were to present a clinical technique for the cementation of implant-supported fixed restorations and to address the major problems of conventional cementation by using an extraoral replica of the implant abutment and zinc oxide cement. A prospective study was conducted to provide data on rates of decementation in the initial period of intraoral service in a private practice setting. After the first 12 months, the decementation rate was less than 6% of implants.

When evaluating the results of the present study, consideration should be given to the fact that only a limited number of patients could be recruited and that patients were followed for only a short observation period of 12 months. Therefore, this study cannot demonstrate the adequacy of this cementing technique for longer periods. The study was conducted to assess whether this technique principally yields sufficient retentive force for the intraoral use of cemented restorations. However, a 12-month interval may be considered sufficient for the diagnosis of cement-related

inflammation of the peri-implant soft tissue and to draw conclusions regarding the presence or absence of excess cement. It was not possible to follow all the patients who received restorations. Furthermore, the cementation and clinical examinations were performed by the same dentist, who was not calibrated. Until recently, microscopic analyses of marginal gaps were lacking. In all cases included in the present study, the original abutment was transferred to the dental laboratory and was used on the master model. Precise control was achieved using a stereomicroscope. Therefore, it can be assumed that the precision of the restoration was acceptable. In case of imprecise restorations, alterations in occlusion would have been detected during intraoral delivery. The individual depths of the subgingival margins were not recorded, and they should be assessed in further studies.

Prosthetic outcomes for cement-retained, implant-supported fixed dental restorations were assessed in a systematic review.<sup>23</sup> Loss of retention was observed to be the most common technical complication in short-term studies (up to 4.6% for permanent cements and up to 15% for temporary cements) as well as in long-term studies with observational periods of more than 5 years of follow-up (up to 16% for permanent cements and up to 22% for temporary cements). Recently, a retrospective comparison of semipermanent (Dycal, Dentsply DeTrey; TempBond, MultidentDental) and permanent (Harvard, Harvard Dental International; Ketac Cem, 3M ESPE; RelyX Unicem, ESPE) cementation of implant-supported single crowns and fixed partial dentures (FPDs) was conducted.<sup>24</sup> In total, 241 patients with 166 FPDs and 232 single crowns were followed over an average of 2.24 years by the authors. Nearly half of both types of restorations were fixed using semipermanent cement. Loss of retention occurred with 35 FPDs (21.1%) and 27 single crowns

(11.6%). The cement used had a significant effect on the loss of retention of FPDs but no effect on the loss of retention of single crowns. The risk of loss of retention for FPDs was estimated to be 3.5 times higher in the semipermanent cementation group than in the permanent cementation group. Based on further clinical observations by the authors, the question of whether abutment roughening may lead to increased retentive force when using this cementation technique should be discussed and assessed.

To select the appropriate cement type, clinicians must balance different considerations. Cements with high retention values (eg, polycarboxylate cements) minimize the risk of accidental decementation but are difficult to remove. This fact complicates the removal of excess cement after cementation and makes it difficult to remove the restoration when necessary, eg, when caused by chipping or abutment loosening. This process might result in the destruction of the crown, which is highly cost-intensive. Cements with low retention values (eg, zinc oxide cements) address this drawback but have an elevated risk of accidental decementation. Another aspect that has to be considered is the radiopacity of the cements. Greater cement residues in the mesial or distal areas may be detected on radiographs after the intraoral delivery of restorations and can be removed immediately if the cement used is radiopaque. Pette et al<sup>25</sup> assessed 18 different cements typically used for luting restorations to implants. Although different resin-based cements did not reveal any radiopacity, cements containing zinc were the most detectable on radiographic analysis.

Until now, the ideal type of cement has not been identified,<sup>23,26</sup> and guidelines for cementation are also lacking. Korsch et al<sup>27</sup> reassessed 126 implants in 71 patients who had undergone cementation up to a maximum of 1.5 years previously using a high-retention cement (methacrylate cement). In all cases, the abutment shoulders were placed at a gingival depth of 1.5 mm or less. In that retrospective clinical observational study, all superstructures and abutments were removed. Nearly 60% of the implants showed cement residues. BOP was noted at 80% of the implant sites with excess cement, and suppuration was observed at 21% of the implant sites. Positive BOP values were reduced and suppuration was eliminated after recementation using zinc oxide cement. In another (prospective) study, 42 implants with signs of peri-implantitis were evaluated<sup>13</sup> using a dental endoscope, which revealed excess cement in 34 implants (81%). At follow-up, 30 days after removal of the excess cement, 25 implants (74%) no longer exhibited signs of peri-implantitis.

In the present study, no cases of peri-implantitis were recorded, and the rates of peri-implant mucositis

were 33% and 22% in those with BOP and control subjects, respectively. Considering the short observation period, this result is in accord with the results reported by Roos-Jansäker et al,<sup>28</sup> who found mucositis rates between 39.6% and 52.3%. The lack of difference in the number of peri-implant mucositis and peri-implantitis between the two groups was unexpected. The present authors hypothesize that because of the material properties of zinc oxide cement, experienced clinicians can successfully remove excess cement residues after intraoral cementation of implant-supported restorations. The findings of Korsch et al<sup>27</sup> may have been different because other cement types were used.

The idea of using the replica technique to facilitate the removal of excess cement extraorally just before intraoral cementation was introduced by Dumbrigue et al<sup>16</sup> in 2002. The authors proposed the use of a “practice abutment” without providing further data on the material or demonstrating the effectiveness of this technique. Later, a fast-setting vinyl polysiloxane was proposed as a material for chairside fabrication of a replica.<sup>17</sup> Chairside time is usually cost-intensive, so in the current study, an abutment replica made of pattern resin was used with a model pin for optimal handling, which was delivered by the dental laboratory. This procedure proved to be cost-effective and allowed a quick course of cementation. Instead of the usual cement removal procedure, which can sometimes be difficult, only a comparably simple cement control procedure needs to be performed. In the authors’ opinion, these advantages will reveal themselves to be even more relevant when different cement types with higher retentive forces are used.

Considering the risks of decay and periodontal disease, this cementation technique should be used exclusively for implant restorations and not in natural teeth.

## CONCLUSIONS

A replica technique, combined with the use of zinc oxide cement, has proven to be effective in achieving sufficient retention for fixed restorations cemented to implants. Decementation rates were not elevated compared with a conventional cementation technique. Therefore, this cementation technique is recommended for clinical use.

Despite the presence of subgingival crown margins, low rates of peri-implant disease (and no improvement for replica technique) were detected after 1.5 years, which may be interpreted as indirect proof of the absence of excess cement. Low rates of decementation are expected in the initial period of intraoral service. Future prospective evaluations with long-term observation periods and different cements

are required to reassess the present study's findings and to compare this cementation technique with other approaches.

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