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Zinc Oxide Non-Eugenol Cement versus Resinous Cement on Single Implant Restoration: A Split-Mouth Study

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Abstract: Cement-retained implant restorations still represents a widely used prosthetic solution today, considering the simple execution, the possibility of correcting the implant axis according to the dental axis and an extremely satisfactory aesthetic. The objective of the study is to evaluate whether resin-based cements are actually more aggressive towards the peri-implant tissue compared to zinc oxide cements. In the present study 18 patients (8 males and 10 females) were examined with a split-mouth design. The follow-up period for patients after delivery of the cement-retained single crown is a maximum of 48 months. A total of 36 implants were inserted and monitored during this period. Clinical and radiographic tests were carried out on all 36 implants, with constant re-evaluation, as well as the occurrence of some prosthetic or biological problems that brought the patient back to visit. The results for both cements were in line with the indications of the respective manufacturers. During the observational period, no implant failed, with a survival rate of 100% on these 36 implants. In conclusion, it is possible to establish that the number of decementations of the cement-retained crowns cemented with Temp Bond non-eugenol was higher, but not statistically significant. In contrast, the biological complications per implant and the MBL were significantly higher in the cement-retained crowns cemented with Implacem.

Keywords: zinc oxide; non-eugenol; resinous cement; implant; crown; cement retained

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1. Introduction

The cement-retained crown on a single implant still represents a widely used solution today, considering the simple execution, the possibility of correcting important dis-parallelisms and an extremely satisfactory aesthetics [1,2].

The possibility of using original abutments of different inclinations and heights, as well as the possibility of manufacturing custom ones, greatly expand the possibilities of use of this prosthetic solution [2,3]. The chance of designing custom abutments allows clinicians to position the prosthetic finish line at the gingival level that is considered suitable to ensure the possibility of eliminating cement remnants [4].

Sailer et al. in their systematic review concluded that cemented reconstructions exhibited more serious biological complications (implant loss, bone loss > 2 mm) while screw-retained reconstructions exhibited more technical problems [2].

The custom abutments also allow us to increase the contact surface between the abutment and the crown structure in such a way as to improve retention even in cases of

reduced vertical dimension, as well as allowing for excellent retention even in the case of the correction of dis-parallelism in cement-retained restoration with multiple implants [4].

The main contraindications to the use of this technique are represented by the difficulty in removing these implant-retained prostheses, which is certainly greater than with screw-retained ones, is the possibility that the cements manifest inflammatory and infectious reactions towards the peri-implant mucous tissues and in the evolution of the peri-implantitis, and the possibility of these cement-retained crowns detaching [4–6].

In order to avoid frequent detachment of these cement-retained prostheses, it is often necessary to use particularly retentive, non-water-soluble cements, often definitive, which can cause serious damages to the delicate peri-implant bone-mucous system if not removed from peri-implant sulcus [7–11].

Notwithstanding the reported data from the previously cited systematic review, Hamed et al. underlined that dental implants are associated with complications leading to implant failure based on the type of restoration that is being used, and that screw-retained implant-supported reconstructions were found to pose fewer biological and technological complications [2,7].

To prevent this complication, and to maintain moderate levels of inflammation in the peri-implant tissues already shown to be more inflamed than in periodontal tissues, it is necessary to use cements that often do not guarantee a great retention of the cement-retained restorations, but which allow disassembly when necessary [4,12–14]. This possibility allows clinicians not to necessarily drill the artifact to unscrew the crown and the abutment together when cemented with definitive cements, but to expose the possibility of untimely de-cementation. The possibility of using water-soluble cements with reduced resistance to disengagement is necessary to ensure long-term sealing of closely spaced abutment preparations with respect to the metal framework [4].

This attitude is recommended to reduce the risk of damage to the components screwed to the implant in this type of implant-supported prosthesis [12–14].

Moreover, the presence of cement in the peri-implant sulcus represents a possible area of bacterial colonization, and the cyto-toxicity of some resinous monomers components of some cements towards gingival fibroblasts has yet to be verified [15–18].

Korsch et al. have indicated the various changes that the microbiota undergoes depending on the type of cement that remains in excess at the level of the prosthetic components and at the interface with the soft tissues [16].

The authors of this study in a previous published one underlined the positive characteristics and suggested the use of a zinc oxide cement, with or without eugenol, for the cementation of cement-retained implant prostheses [4].

In this study the recommended cement, zinc oxide non-eugenol Temp Bond (Kerr Corporation, Orange, CA, USA) was compared with a self-cured resin cement without eugenol considered for temporary cementation on implants, Implacem Automix (Dentalica S.p.A, Milan, Italy) [4,19].

In the present study, cementation with two different types of cement is compared, keeping the other variables stable, such as the implant type, the abutment characteristics, the materials of which the prosthetic crown is made, and with the added value of the split-mouth design, which allows us to further reduce the variables included in the following study.

Therefore, the aim of this clinical study was to evaluate the retention rate, and the peri-implant biological complications, of cement-retained crowns cemented with these two types of cement in a split-mouth model study. The null hypothesis was that there would be no difference on the retention rate and on biological implant complications between Temp Bond non-eugenol and Implacem cement.

2. Materials and Methods

2.1. Study Design

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Campus Bio-Medico University of Rome.

A total of 19 patients (9 males and 10 females) were included in this study and initially evaluated clinically and radiographically for this single-blinded, single-center split-mouth design trial. One patient was excluded, not having followed the agreed recall table. After this selection, the results of 18 patients (8 males and 10 females) were processed.

The follow-up period for patients after delivery of the cement-retained single crowns is a maximum of 48 months.

A total of 36 implants Tapered Internal Laser-Lok® (BioHorizons, Birmingham, AL, USA) were inserted and monitored in this period. Clinical and radiographic tests were carried out on all 36 implants, with constant re-evaluation, as well as the occurrence of some prosthetic or biological problems that brought the patient back to visit.

The implant diameters used were 3.8 mm, 4.2 mm, and 4.6 mm. The implant lengths used were 7.5 mm, 9 mm, 10.5 mm, and 12 mm.

No implant has failed in these four years following the Pisa consensus statement of the ICOI Conference 2007.

2.2. Surgical Procedure

Patients scheduled for surgery were prescribed systemic amoxicillin/clavulanic acid (Augmentin, GlaxoSmithkline, Italy), 1 g, twice a day for 6 days, and a chlorhexidine digluconate solution 0.12% (Dentosan 0.12%, Johnson & Johnson, New Brunswick, NJ, USA) rinse (twice daily for 1 min). After local anesthesia by infiltration using articaine/epinephrine (Ecocain 20 mg/mL, Molteni Dental, Milano, Italy), surgical access with a mid-crestal incision in the center of the edentulous ridge was performed. A full-thickness flap was carried out to expose the crest and the vestibular limit of the alveolar bone.

The choice of the full-thickness flap and the mid-crestal incision could vary slightly depending on the amount of keratinized tissue. In cases in which the edentulous crest did not guarantee at least 2 mm of keratinized tissues around the implant, the soft tissues augmentation was practiced with Novomatrix, a pre-hydrated porcine acellular dermal matrix (NovoMatrixTM Reconstructive Tissue Matrix; BioHorizons, Birmingham, AL, USA) at the first intervention or at the second stage surgery [20].

Following implant placement, the flap was sutured without tension using 4.0 or 5.0 monofilament sutures which were left in place for 10 days. As a two-stage technique the implant was submerged, and the second surgical stage was carried out after three months.

This procedure was performed by a mid-crestal minimal incision, slightly larger than the coronal diameter of the implant. Once the healing screw was inserted, suturing was not necessary in most cases, and where a larger flap was needed, mainly for soft tissue management, the flap was sutured without tension using 4.0 or 5.0 monofilament sutures which were left in place for 10 days.

Each submerged implant received a titanium healing abutment in height varying from 2 to 4 mm.

2.3. Prosthetic Procedures

With a totally analog workflow, the cement-retained crowns with a Cr-Co laser-sintered structure and layered ceramic as an aesthetic coating were delivered in two months. The prosthetic finish line for each crown was positioned 1 mm intra-sulcular, with standard-sized peri-implant mucous height.

Patients were recalled after the first month after the setting, and then every 4 months for the first year. The call for the following years was variable, but for all it was at least twice a year.

Computer-assisted image analysis was used to evaluate mesial and distal bone levels on periapical intraoral radiography. The marginal bone loss was measured at baseline

(implant placement) at 24 months and 48 months. All measurements were carried out by a single trained examiner who had previously undergone a calibration session.

The clinical examination at 24 months and 48 months included an assessment of the plaque index (PI), gingival index (GI), probing depth (PD), bleeding on probing (BoP) at six sites around the implant. Moreover, mucosal recession (REC) was recorded [9,20–23].

2.4. Descriptive Statistics

Descriptive statistics were provided by presenting means and standard deviations data and frequencies for categorical variables. The non-parametric data were analyzed using non-parametric Mann–Whitney U and Friedman 1-way ANOVA tests to evaluate the differences in retention rates, at a 5% significance level. All statistical analyses were carried out using the statistical package for Social Sciences (SPSS) software, version 17.0 (SPSS Inc., Chicago, IL, USA) and MedCalc version 9.3.2 (MedCalc Software, Mariakerke, Belgium).

3. Results

The results for both cements were in line with the indications of the respective manufacturers. During the observational period, no implant failed, with a survival rate of 100% on these 36 implants. The complications manifested in these 48 months are indicated in Table 1. The clinical parameters appear quite similar for both cements, increasing in smaller implant diameters. Furthermore, the marginal bone levels in Implacem-cemented single crowns are worse than in Temp Bond-cemented single crowns.

Table 1. Characteristics and complications of the 36 cement-retained implant-supported single crowns with the two different cements. (I) Implacem; (T) Temp Bond; (X months) Months to the intervention.

		Tooth	Decementation Frequency	Patient Age/Sex
1	3.8 × 10.5	3.6 (I)	0	36 (M)
2	3.8 × 10.5	3.6 (I)	0	38 (F)
3	3.8 × 10.5	4.6 (T)	0	42 (F)
4	3.8 × 12	3.6 (I)	0	50 (M)
5	3.8 × 12	3.6 (T)	1 (24 months)	33 (F)
6	3.8 × 12	3.6 (I)	0	28 (M)
7	3.8 × 12	3.6 (I)	0	44 (F)
8	3.8 × 12	3.6 (T)	0	47 (F)
9	3.8 × 12	4.6 (I)	1 (36 months)	25 (M)
10	3.8 × 12	4.6 (I)	0	36 (M)
11	3.8 × 12	4.6 (T)	0	36 (M)
12	4.2 × 9	4.6 (I)	0	47 (F)
13	4.2 × 9	3.6 (I)	1 (38 months)	30 (F)
14	4.2 × 9	4.6 (T)	0	28 (M)
15	4.2 × 9	4.6 (I)	0	40 (F)
16	4.2 × 10.5	3.6 (T)	1 (36 months)	25 (M)
17	4.2 × 10.5	3.6 (I)	0	42 (F)
18	4.2 × 10.5	3.6 (T)	0	26 (M)
19	4.2 × 10.5	4.6 (T)	0	42 (F)
20	4.2 × 10.5	4.6 (I)	0	25 (M)
21	4.2 × 12	3.6 (I)	0	40 (F)

Table 1. *Cont.*

		Tooth	Decementation Frequency	Patient Age/Sex
22	4.2 × 12	3.6 (T)	0	25 (M)
23	4.2 × 12	4.6 (I)	1 (44 months)	26 (M)
24	4.2 × 12	4.6 (T)	0	44 (F)
25	4.2 × 12	4.6 (T)	0	38 (F)
26	4.6 × 7.5	3.6 (T)	1 (36 months)	28 (F)
27	4.6 × 7.5	3.6 (T)	0	32 (M)
28	4.6 × 7.5	3.6 (T)	0	40 (F)
29	4.6 × 7.5	3.6 (I)	0	42 (F)
30	4.6 × 7.5	4.6 (I)	0	33 (F)
31	4.6 × 7.5	4.6 (T)	0	50 (M)
32	4.6 × 7.5	4.6 (T)	0	30 (F)
33	4.6 × 7.5	4.6 (T)	0	40 (F)
34	4.6 × 7.5	4.6 (I)	0	32 (M)
35	4.6 × 10.5	3.6 (T)	1 (30 months)	36 (M)
36	4.6 × 10.5	4.6 (I)	0	28 (F)

In two cases a progressive bone loss distal to the implant led to surgical curettage of the vertical bone defect diagnosed within the first 24 months, where residues of Implacem cement were found in both cases (also indicated in Table 1). This consequence has never occurred with Temp Bond.

The levels of inflammation detectable by clinical parameters suggest a worse condition in the interproximal spaces distal to the single crowns, both for the difficulty in maintaining adequate levels of oral hygiene, and for the often more abundant emergency profiles of these crowns.

Overall, 7 decementations of the 36 cement-retained single crowns occurred in 48 months, with 4 (22.2%) decementations for the crowns cemented with Temp Bond and 3 (16.7%) for the crowns cemented with Implacem. Therefore, this difference is not statistically significant, considering the results obtained from the two different cements to be similar and all the different variables included in a split-mouth study, including occlusion, antagonist, interproximal contact point, abutment surface, etc.

There were different values of the MBL (marginal bone loss), which in two cases forced an early intervention for the surgical removal of cement excess in a deep portion of the peri-implant sulcus, which in fact shows greater bone loss with this type of cement (indicated in Table 2).

Table 2. Periodontal indices and MBL (marginal bone loss) measured mesial and distal.

	N. Fixture	Survival Rate	PI	GI	PD	BOP	REC	MBL—Mesial	MBL—Distal
3.8 (TB)	4	100%	0.24 ± 0.30	1.14 ± 0.38	2.44 ± 0.38	0.24 ± 0.30	0.7 ± 0.2	1.2 ± 0.6 mm	1.3 ± 0.7 mm
4.2 (TB)	7	100%	0.23 ± 0.31	1.25 ± 0.33	2.14 ± 0.33	0.23 ± 0.30	0.6 ± 0.2	1.3 ± 0.7 mm	1.4 ± 0.6 mm
4.6 (TB)	7	100%	0.20 ± 0.18	1.14 ± 0.34	2.22 ± 0.38	0.22 ± 0.28	0.6 ± 0.2	1.2 ± 0.7 mm	1.3 ± 0.7 mm
3.8 (I)	7	100%	0.25 ± 0.29	1.28 ± 0.34	2.84 ± 0.28	0.24 ± 0.30	0.8 ± 0.2	1.6 ± 0.9 mm	1.7 ± 0.9 mm
4.2 (I)	7	100%	0.24 ± 0.30	1.24 ± 0.38	2.60 ± 0.30	0.26 ± 0.28	0.8 ± 0.2	1.5 ± 0.9 mm	1.6 ± 1.2 mm *
4.6 (I)	4	100%	0.20 ± 0.19	1.16 ± 0.38	2.53 ± 0.22	0.28 ± 0.30	0.7 ± 0.2	1.6 ± 0.8 mm	1.6 ± 0.9 mm *

* Statistically significant difference between the two different types of cement in relation to the periodontal index ($p = 0.026$).

4. Discussion

The two provisional cements showed similar results with regard to decementations, with a slightly higher frequency for Temp Bond. This study, with a split-mouth design, permitted an intraindividual comparison of clinical parameters. Both cements have good radiopacity, a necessary condition for finding cement excess on a radiographic level, always remembering that a maximum of 50% of cement excess can be found in this way, due to the overlap of the vestibular and lingual residues with the implant/abutment complex [4].

Reda et al. reported in a systematic review published in 2022 the ideal characteristics of cements for cement-retained implant restorations, including the following [4]:

- although pathologies caused by excess cement are low, resinous cements should be avoided due to the free monomers present in them, which are toxic for the soft tissues;
- the use of eugenol-free oxide cement made it possible to find no residues in the soft tissues but only in adhesion to the implant and prosthetic components;
- the provisional zinc oxide cements, also eugenol-free, easily recognizable in intraoral radiography, are easily removed, and allow for easier removal of prosthetic restorations, unlike definitive cements;
- and the different grades of retentive forces provided by these cements do not seem to have a clinical effect on the decementation of the restorations.

Certainly, the possibility of inserting the implant in a prosthetically guided way, with digital prosthetic planning of the better implant position, thus avoiding crowns with an emergence profile greater than 30 degrees and with convex and cleanable profiles, represents a point in favor of cleaning the restoration and removing intra-sulcular cement remnants [21,23,24]. Furthermore, the possibility of using screw-retained prostheses allows the prosthetic profiles to be managed correctly even with emerging profiles with important vertical over-contours, however not cleanable, where there is no risk of important cements remnants in the prosthetic undercuts [23,24].

Furthermore, considering digital technologies and the development of prosthetic materials that currently allow for various solutions, it would be interesting for future studies to also consider the relationship that these cements have with resins used as intermediate components or as veneering material and zirconia abutments [25–27]. Considering the wider margin of modification of the shapes in the preparation of the implant abutment, the decision whether or not to place a shoulder at the level of the finishing line can represent an element of fundamental importance regarding the possibility that there is accumulation of cement in the peri-implant sulcus [26,27]. The variables are different, and the selection of the cement should be performed according to the type of material of which the abutment is made and of which the framework of the prosthetic work is made [4].

As regards the tissue effects of resin cements, future studies will be needed to verify the cytotoxicity of the free resin monomer, and how this manifests itself over time in peri-implant tissues health. For now, the presence of residues in the peri-implant sulcus, however, maintains the highest levels of inflammation, and often it is necessary to perform a surgical removal of these residues adhering to the metal implant components [18,27].

Moreover, the behavior of the two cements is extremely different in terms of adhesion to dental, metal or peri-implant soft tissue surfaces, and in relation to this the inflammatory response to this irritating stimulus changes [18,27]. Although the resin-based cement, both in terms of color and consistency, is quite rubbery and it is easily cleaned after hardening, it still causes a worse biological problem than zinc oxide eugenol cements, which are more difficult to remove in some situations, but whose permanence in the sulcus does not induce important changes.

The 1 mm intrasulcular positioning of the prosthetic finish line represents an enormous advantage in terms of cement excess removal, a procedure which can still be complex considering important prosthetic undercuts, particularly high peri-implant mucosal cones, or important implant inclinations [27].

Placing a very coronal finish line, however, reduces the retention surface of the abutment, which could affect the decementation rate of single crowns, or it could expose in

the short term to an aesthetic failure of the restoration, which with a few millimeters of gingival recession could show the metal components of its structure.

In this context, Linkevicius et al. measured the relation between the area of cement remnants and the total area of soft tissue contour [28].

Depending on the depth of the prosthetic finish line in the peri-implant sulcus, cement excess increases from 1.4% with the juxta-gingival line, up to 7.1% at 3 mm depth. To obtain the best result in terms of reduction of cement excess, the line should be placed 1 mm under the gingival margin, always considering the aesthetics of the prosthetic material chosen for the definitive restoration. The cement excess removal, even in these conditions, is not safe, always considering the mesial and distal areas, where the finish line often runs deeper due to the interproximal papillae [28].

As also reported by Linkevicious et al., references such as tissue stability with a cement-retained prosthesis are different from screw-retained solutions. The present study, considering the position of the prosthetic line more coronal, indeed validated from a clinical point of view what Linkevicious et al. had reported as the amount of excess cement present as a surface. From this point of view, it is important to consider that this study was performed exclusively on posterior single cemented crowns. The authors of the present study expect different results if the analysis were conducted on small bridges or on complete cemented and screwed arches, considering the different profile of the prosthetic rehabilitation and the extent of the undercuts present in more complex rehabilitations. We can further suggest that there will be an expected result difference even if the same study with the same implants will be performed in the anterior sextant, where, although the prosthetic finishing line could be inserted deeper to avoid showing a metal component of the structure prosthetics, the ease of cleaning excess cement has certainly increased [29]. From this point of view, it is also possible to always suggest the choice of prosthetic solutions, as regards more extensive prostheses, more easily removable and cleanable, perhaps with screwed solutions or simply retained on implants [29]. It is evident that from this point of view, the greater the volume of the prosthesis, the greater the possibility of accumulation between the various prosthetic and intra-osseous components of this. Evaluating a complete arch, the less possibility of having cleansable profiles exists whether it is a screw-retained or a cemented-retained prosthesis, but the possibility of easily disassembling, and the different thicknesses and profiles that a screwed solution guarantees, allowed with this solution to deliver an easier to maintain prosthesis. In the light of these results, the authors suggest avoiding the use of cements of this type, unless there are particular clinical needs which may require the use of cements capable of bridging clinically unacceptable gaps between the different protein components.

The clinical parameters appear quite similar for both cements, increasing in smaller implant diameters, perhaps due to the difficulty in maintaining hygiene in crowns with a particularly abundant emergence profile (greater than 30 degrees).

Furthermore, the marginal bone levels in Implacem-cemented single crowns are worse than in Temp Bond-cemented single crowns, perhaps justifying a particular aggressiveness towards tissues by this type of cement, or in any case the levels of major tissue inflammation mediators [12,13].

It is therefore important to use temporary cements that can be removed more easily in the gingival sulcus, avoiding definitive cements and adhesive cements [4,30].

As pointed out by Korsch et al., implants whose supra-structures were fixed with a methacrylate-based cement apparently have more oral pathogenic bacteria in the peri-implant sulcus than implants that were cemented with zinc oxide eugenol cement, and it is perhaps also to this microbiological aspect that it is possible to correlate some clinical aspects found in the present study [30].

The possibility of performing a periapical intraoral radiograph is recommended at the end of the cementation procedure, to help in the recognition of interproximal excess cement, where, as mentioned above, the removal is more complex [31,32].

The limitations of this study are the short follow-up period (48 months), and the inclusion of other variables that cannot be excluded from a split-mouth study, i.e., different position in M/D with respect to the alveolar crest, the 3a-dimensional implant position, the distance to the adjacent teeth, the thickness of the residual buccal wall and the thickness of the residual keratinized tissues.

5. Conclusions

The number of decementations of the cement-retained crowns cemented with Temp Bond non-eugenol was higher, but not statistically significant.

In contrast, the biological complications per implant and the MBL were significantly higher in the cement-retained crowns cemented with Implacem.

For this reason, the use of provisional zinc oxide cements, which are also eugenol-free, easily recognizable in intraoral radiography on the mesial and distal aspects, easily removable, and allow for easier removal of prosthetic restorations when clinically desired, unlike definitive cements, is suggested.

It is not clear whether the reason for the worst clinical integration of resin cement residues is due to its aggressiveness towards the epitalial cells or whether it allows colonization by periodontopathogenic bacteria, leading to a worsening of the periodontal indices.

In light of this result, we recommend carefully evaluating the need to cement cement-retained implant restoration with non-water-soluble resin cements.

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