Review Article

Shape memory attachment as a possible modality to prevent peri-implant disease—a narrative review

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Background and Objectives: Peri-implantitis is the implant equivalent of gum disease and the associated risk factors are similar to those of periodontal disease, such poor plaque control, smoking, and systemic conditions. Some risk factors are iatrogenic and this review discusses the literature specifically investigating the positive relationship that exists between peri-implantitis and cement-retained implant restorations.

Methods: A data-based search was performed by using PubMed database whereby articles published between 2000 and 2021 in English were included in the search with the following key words: peri-implantitis, peri-implant mucositis, excess cement, peri-implant health, screw-retained. It was found that excess dental cement around implant restorations has been correlated with swelling, purulence, bleeding, deeper pockets, peri-implant bone loss, and in extreme cases implant loss. Studies that evaluated the peri-implant tissue response to removal of the excess cement around cement-retained implant restorations observed a stark resolution of clinical and endoscopic signs of peri-implant disease in majority of cases.

Key Content and Findings: Although precautions can be taken to minimize the amount of cement extrusion, the risk of peri-implantitis is still concerning with conventional cement-retained implant restorations. Shape memory alloys have been proposed as a viable modality to retain implant prosthetics and restorations.

Conclusions: In lieu of cement as the method of retention, the shape-memory implant abutment system has been shown to be applicable to a variety of case complexities and most importantly has no negative effect on peri-implant tissues. This novel alternative is a possible effective method to prevent peri-implantitis instead of treating the disease.

Keywords: Peri-implant disease; shape-memory; nitinol

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Introduction

Since the discovery of bone healing around titanium chambers by Dr. Branemark in 1952, implants have advanced in technology, materials, and knowledge. Implants are fundamentally restored with one of two ways: screw or cement. The main advantages of screw-retained implant crowns are retrievability and application in minimal interocclusal spaces. However, the disadvantages of screw-retained restorations are the effect of the access hole on esthetics and occlusion and difficulty in obtaining passive fit in multiple splinted units due to the lack of spatial relief (i.e., cement space). Cement-retained implant restorations

Table 1 The search strategy summary

Items	Specification
Date of search	Oct 1st 2021
Databases and other sources searched	PubMed
Search terms used	Peri-implantitis; peri-implant mucositis; excess cement; peri-implant health; screw-retained
Timeframe	01/01/2000–10/1/2021
Inclusion and exclusion criteria	English
Selection process	Searched and Reviewed by both 1st and 2nd authors independently and selected after discussion

are advantageous in that esthetics are enhanced due to the absence of an access hole, there is more freedom in terms of implant position/angulation, and the protocol for restoration is similar to a traditional tooth (1). The greatest disadvantage to cement-retained implant restorations is the inability to remove excess cement at the crown margin, despite proper cementation protocols and presence of shallower subgingival margins (2-4). The effect of excess cement on peri-implant tissues has been heavily reported in the literature. Peri-implant mucositis includes acute complications such as swelling, exudate, bleeding, deeper probing depths, and peri-implantitis typically also includes radiographic loss of peri-implant bone often associated with residual cement around cement-retained implant crowns. Also, more severe complications such as implant loss has also been related to cement-retained implant restorations. These reported complications can arise from weeks to even years after cementation (5,6).

While screw retained restorations seem to be popular to overcome the negative effects of cement retention, the higher mechanical fracture rate and lack of ideal occlusal contact spots are reasons used to not utilize these screw-retained restorations. The aim of this review was to generate discussion around a novel crown retention method using shape memory alloy to eliminate the risk of residual cement induced peri-implant diseases while keeping the restoration retrievable. We present the following article in accordance with the Narrative Review reporting checklist (available at https://fomm.amegroups.com/article/view/10.21037/fomm-21-118/rc).

Methods

A search on the English literature pertaining to peri-implant diseases and its associated risk factors was conducted. Specially the using of shape memory alloys to retain prosthetics and restorations was also sought (see *Table 1*).

Discussion

Cement-retained restorations have a poorer outcome measure on certain assessment tools. Weber *et al.* evaluated the health of peri-implant tissues surrounding cement- and screw-retained implant restorations with parameters such as plaque index, bleeding index, and gingival levels. Peri-implant soft tissues had a more favorable response to screw-retained than cement-retained crowns. Throughout the 3-year follow up period, cement-retained implant crowns showed increased bleeding with a consistent level of plaque while screw-retained crowns had bleeding indices that were stable with decreased plaque indices over time (7). A comparison of the marginal gaps between cement- and screw-retained implant crowns revealed significantly larger marginal gaps in cement-retained crowns (54.4±18.1 μm) than screw-retained crowns (8.8±5.7 μm). Additionally, the size of the marginal gap was dependent on the type of cement (glass ionomer 57.4±20.2 μm, zinc phosphate 67.4±15.9 μm) (8). Korsch *et al.* investigated the type of luting cement (methacrylate *vs.* zinc oxide eugenol) and association to peri-implantitis. For cases luted with methacrylate cement, 62% of implants presented with excess cement and significantly more bleeding and suppuration than crowns luted with zinc oxide eugenol cement. The amount of excess methacrylate cement was related to the radiolucent property of the cement and inability to adequately detect and remove it from the sulcus (9). These studies indicate that cement-retained implant restorations have a greater risk of peri-implantitis compared to screw-retained implant restorations not only due to increased plaque retention attributed to the roughness of the crown-implant interface, but also due to the influence of cement type on marginal gap size and amount of excess

cement.

A prospective study by Wilson reported that 81% of cases presenting with peri-implant disease showed evidence of excess dental cement around the restoration (10). Removal of the excess cement led to no clinical and no endoscopic signs of peri-implant disease in 74% of these cases. In another retrospective study by Korsch *et al.*, 59.5% of cement-retained implants included in the study presented with excess cement, with 80% of implants presenting with bleeding on probing and 21.3% of implants presenting with suppuration (11). With removal of the residual cement and careful re-cementation with Temp-bond, there was a 76.9% resolution of bleeding on probing and no evidence of suppuration (12). The results of these studies reveal a positive relationship between peri-implantitis and residual cement. A significant number of implants with peri-implant disease had a resolution of clinical signs through removal of the excess cement, however, the fact remains that the disease process was established and the risk of peri-implantitis is not eliminated completely, but merely decreased. The peri-implant complications associated with residual cement has been shown to range from bleeding on probing to complete implant loss (5,6). When the complications are reversible, treatment modalities such as removal of cement are appropriate, but with irreversible complications, palliative treatment is not sufficient. Different precise cementation protocols and careful handling have been proposed to minimize excess cement, but studies have shown that extrusion of cement is inevitable in a traditional cement-retained implant restoration (2). Thus, the literature directs the focus to completely avoiding the intraoral use of cement in implant restorations. There are more recent friction-fit implant restorations that have been reported as case reports (13). They appear to eliminate the intra-oral cementation process, however, the long-term implications of removal and reseating of the same restorations remain unknown.

The shape-memory implant abutment system was developed as a novel alternative of retaining implant restorations that combines the advantages of and eliminates the limitations of cement- and screw-retained implant restorations. This system involves a nickel-titanium (nitinol) sleeve that has the ability to transform and switch configurations, which allows the prosthesis to lock and unlock onto the abutment (14). In a 6-month pilot clinical study, eight participants were recruited for restoration with the nitinol shape-memory-retained abutment system for a single osseointegrated implant in a posterior quadrant (15). The parameters measured were oral hygiene, probing depths, plaque index, gingival index, proximal contacts, and occlusal contacts. Comparing the baseline values to the follow-up appointment (minimum of 6 months), minimal differences were noted. Six out of 8 participants had probing depths of less than 3 mm, plaque and gingival indices scores of "0", no visible plaque retention, and absence of peri-implant inflammation throughout the follow-up period. One participant had improved plaque and gingival indices and another participant had indices of "1" that remained unchanged throughout the follow-up period. Participants in the study had no issues or discomfort with the final prosthesis. The results of this study suggest that the shape-memory implant abutment system does not negatively affect peri-implant health, as seen with traditional cement-retention. An evaluation of the wear and retention performance of these shape-memory abutment systems after 6 months of clinical use was completed through scanning electron microscopy and tensile testing, respectively. Results showed no evidence of damage to the shape-memory alloy sleeves and no significant differences in retention values before and after clinical use. The mean retention force of control nitinol sleeves was higher (480±37 N) than that of a commercial resin cement (336.3±188 N). The mean retention force of nitinol sleeves remained unchanged after 5,000 compression load cycles compared to traditional cement which decreased in retention force (15). Furthermore, the application of this shape-memory system is not limited to conventional single unit restorations and can be efficiently used for treatment with full-arch prostheses (16).

The advantages and disadvantages of the various retention types are summarized in *Table 2*.

Conclusions

It is estimated that in the United States, 178 million people are missing at least one tooth and about 40 million people are missing all their teeth (17). With the advancements in dental implants and associated technologies, implants have become a fundamental and predictable treatment option for many people. Prosthetic rehabilitation with implants is generally screw- or cement-retained, each with its advantages and disadvantages. One of the concerning complications associated with implants is peri-implantitis. Studies in the literature have shown the positive correlation of residual cement and peri-implant disease. The risk of peri-implantitis associated with excess cement poses a

Table 2 The advantages and disadvantages of the various retention types

Items	Advantages	Disadvantages
Cement	Ease of fabrication and clinical steps similar to other indirect restorations	Risk of peri-implantitis
	Control of occlusal contact	
	Restoration without an occlusal hole	
Screw	Retrievable	Occlusal contact interference with screw access channel
		Higher risk of porcelain chipping/fracture
Friction	Control of occlusal contact	Need to tap the restoration on and off
	Restoration without an occlusal hole	
Shape-memory sleeve	Retrievable	Need of an additional activator device to unlock the restoration
	Ease of fabrication and clinical steps similar to other indirect restorations	
	Control of occlusal contact	
	Restoration without an occlusal hole	

significant problem considering that patients are readily rehabilitated with cement-retained restorations which are arguably preferred by many specialists and general dentists over screw-retained restorations (17). The strong association between cement and peri-implantitis behooves us to reappraise cement-retention for implant restorations as a standard of care. The shape-memory implant abutment system is a third method of retention for implant restorations that can be easily incorporated into clinical practice, has excellent clinical performance, does not sacrifice esthetics for retrievability, and eliminates the need for cement. Without the presence of cement, the risk of peri-implantitis can potentially be significantly reduced, and the nitinol shape-memory sleeve seems to be a promising alternative solution to accomplish just that.

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Footnote

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