Stomatologija, Baltic Dental and Maxillofacial Journal, 19: 44-50, 2017

The comparison of cement- and screw-retained crowns from technical and biological points of view

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SUMMARY

Objective. The aim of this review was to evaluate the most common complications in implant prosthodontics with porcelain-fused-to-metal crowns, to evaluate the influence of biomechanical properties on fractures and cracks of veneered porcelain, and to compare the effects of crowns with different connections on soft tissues.

Material and Methods. A search of literature in the English language between 2009 and 2015 was conducted using the following databases: Medline via PubMed, Science Direct, Wiley online library, Taylor& Francis, and Cochrane library. In total, 10 studies that met the inclusion criteria were found.

Results. Four investigations showed that technical complications more often occurred in screw-retained prostheses, although two studies concluded that cement-retained crowns were also susceptible to technical complications. Two investigations showed that the deeper the abutment margin was subgingivally, the more excess cement was left in the peri-implant sulcus. Four studies concluded that cement-retained prostheses were more susceptible to biological complications, but two investigations also showed that biological complications were observed in tissues adjacent to screw-retained crowns.

Conclusions. The research of literature data for the last five years showed that screw-retained crowns demonstrated more failures such as porcelain cracks and fractures or screw loosening, while cement-retained crowns caused more severe biological complications such as peri-implant soft tissue inflammation or pathological bone resorption.

Key words: cement-retained restorations, screw-retained restorations, implant-supported prosthesis, peri-implant soft tissue health, biological and technical complications of implant restorations.

INTRODUCTION

Implant-supported reconstructions for dental arch defects became the primary option due to longevity, good aesthetics, and comfort. One of the most important decisions when using dental implants in prosthodontics is the choice of the final crown and implant connection type via abutment (1). The implant-crown abutment can be either cement- or screw-retained (2, 3). Both of these connection types have their advantages and disadvantages (1, 2, 4). Before choosing the connection type of the implant and the crown, the prosthodontist has to evaluate the prospective requirements and opportunities of the crown and abutment replacement, the peri-implant soft tissue health, residual excess cement cleaning opportunities, interocclusal height, the aesthetics of the reconstruction, marginal and occlusal precision, passive fit, compressive crown-abutment-implant-bone loading, retention, cost and ease of fabrication, and the probability of prosthetic complications (1, 2, 5-10).

The aim of this study was to identify the most common biological and mechanical complications in implant prosthodontics, to evaluate the influence of biomechanical properties that cause fractures and cracks of veneered porcelain, to compare the effects of crowns of different connections on soft tissues.

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SELECTION CRITERIA OF THE STUDIES, SEARCH METHODS AND STRATEGY

A systematic literature review was carried out to identify relevant studies reporting data on implant-supported restorations. The search of literature was conducted using the following databases: Medline via PubMed, Science Direct, Wiley online library, Taylor & Francis, and Cochrane library. During the search, we used the following terms and their combinations: "cement-retained restorations" or "screw-retained restorations" or "implant-supported prosthesis" and "peri-implant soft tissue health" and "biological complications of implant restorations" and "technical complications of implant restorations". The initial search for articles in the English language for the period of 2009-2015 retrieved 1345 papers. Where it was clear from the abstract that the study is not focused on the topic of this literature review, full-text articles were excluded. After the exclusion of the unsuitable articles based on the exclusion criteria, 10 clinical studies were found to meet the inclusion criteria (Figure).

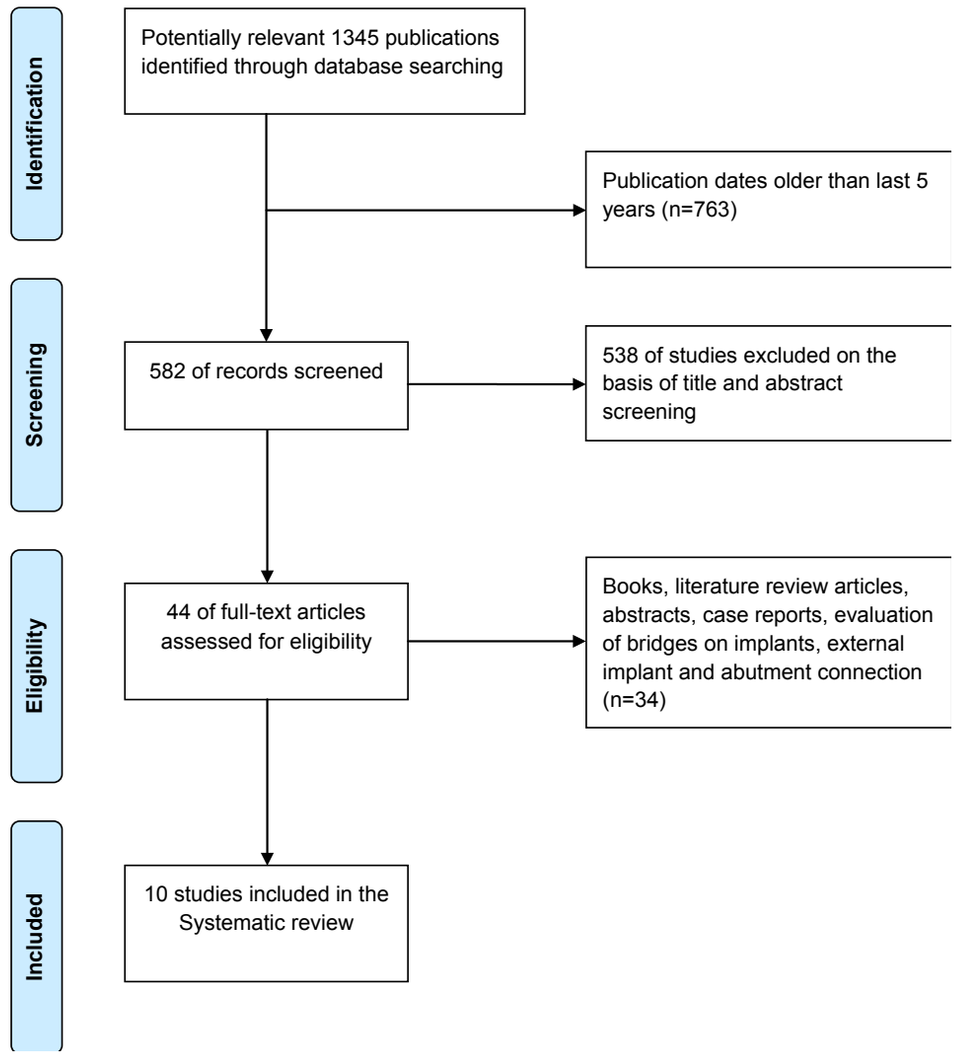

Fig. Flow diagram of the literature search strategy

Inclusion criteria. Research papers were included if they met the following criteria: studies where separate crowns on the implants are evaluated, where the connection between the implant and the abutment is internal, in vivo studies where porcelain-fused-to-metal crowns are investigated, and thus the influence of the metal framework on porcelain resistance and crown fabrication techniques is analyzed, in vitro studies, using CAD or gypsium models with metal abutments and crowns, randomized or quazi-randomized controlled clinical studies.

Exclusion criteria. The papers were excluded if they analyzed bridges on the implants, external implant and abutment connection, systematic literature reviews, older than 5 year year-old studies, abstracts available only and case reports.

RESULTS

Data extraction. The selected studies were divided into groups according to the type of the study: evaluation of technical complications and evaluation of biological complications of cement- and screw-retained crowns.

Data of evaluation of technical complications of cement- and screw-retained crowns were systematized in assessing kind of experimence, amount of specimens, amount of testing groups, type of connection between the implant and the abutment, examinations methods, load direction and volume, type of cement (Table 1).

Data of evaluation of biological complications of cement- and screw-retained crowns were systematized in assessing kind of experimence,

amount of specimens, amount of testing groups, type of connection between the implant and the abutment, examinations methods, type of cement (Table 2).

Table 1. The criteria of articles' qualitative evaluation

Author of the article	Year	Kind of experimence	Amount of specimens	Amount of testing groups, type of connection between the implant and the abutment	Examinations methods	Load direction	Loading volume	Type of cement	Results from technical points of view
Cicciu M *et al.* (23)	2014	*In vitro*	Two virtual three-dimensional CAD models. Implant and crown was recreated following physic-chemical characteristics.	Cement-retained and screw-retained crowns.	Finite element and Von Mises analysis. Stress distribution on the occlusal surface was examined.	Axial load.	400 N.	–	Stress distribution on the occlusal surface was higher on screw-retained crown (22 MPa) than cement-retained crown (10 MPa).
Barbosa da Rocha PV *et al.* (9)	2013	*In vitro*	16 implants with metal crowns.	8 cement-retained and 8 cement-retained crowns with a screw access channel.	Universal load-testing machine.	Axial load.	Untill separation of cemented abutment on the casting.	Self-adhesive resin cement.	There were no statistically significant difference between the groups ($p > 0.05$).
Al-Omari WM *et al.* (15)	2010	*In vitro*	40 implants with metal-ceramic crowns.	4 groups of 10 specimens each. Group SRC: screw-retained; Group SRO: screw-retained, screw access placed toward the buccal cusp; Group CRP: cement-retained; Group CSC: cement-retained with the screw access hole.	Universal load-testing machine.	Axial load.	Until porcelain-fracture.	Zinc phosphate cement.	Groups SRC, SRO and CSC required a significantly lower force to fracture the porcelain than did the CRP ($P<0.05$).
Freitas AC Jr *et al.* (6)	2011	*In vitro*	84 implants with metal crowns.	2 groups: screw and cement-retained crowns.	Specimens were subjected to accelerated life-testing in water.	Axial load.	150 N.	Self-adhesive resin cement.	Cement-retained group presented the higher realiability (0.96) than screw-retained (0.64).
Sherif S *et al.* (22)	2011	*In vivo* 5-year period	102 patients with 214 single implant-supported metal-ceramic restorations.	Screw and cement-retained restorations.	Soft tissue and restorative complications were assessed.	–	–	Various.	No statistically significant difference in survival between the screw- and cement-retained groups ($P=0.45$).
Nissan J *et al.* (2)	2011	*In vivo* 15-year follow up	38 patients with 221 single implant-supported metal-ceramic restorations.	Screw and cement-retained restorations.	Soft tissue and restorative complications were assessed.	–	–	Temporary cement – Temp Bond.	Ceramic fracture ($P<0.001$), abutment screw loosening ($P=0.001$) occured statistically significantly more often in screw retained restorations.

DISCUSSION

Both implant and crown connection types are capable of providing successful treatment results. Cement-retained restorations offer better passivity of fit, which helps to improve force loading characteristics when biting, comparing to screw-retained restorations (1, 2, 6, 8, 9, 11-15). Other advantages

Table 2. Analyzed researches' results

Author of the article	Year	Kind of experimence	Amount of specimens	Amount of testing groups, type of connection between the implant and the abutment	Examinations methods	Type of cement	Results from biological points of view
Linkevicius T *et al.* (25)	2011	*In vitro*	25 casts with embeeded implant analogs and flexible soft-tissue imitation.	Cement-retained metal crowns were cemented on individual abutments with different position of the margin.	Specimens divided equally into 5 groups. After cementation and cleaning cement, crowns were removed and Adobe Photoshop was used for evaluation, cement remnants were also weighed.	Resin-modified glass-ionomer cement.	When the restoration margins were located deeper subgingivally, the undetected cement quantity was higher (P=0).
Linkevicius T *et al.* (26)	2013	*In vivo*	53 patients treated with 53 single implant-supported metal-ceramic crowns.	Cement-retained metal ceramic crowns with occlussal hole cemented on implants abutments with different subgingival location.	After cleaning, radiograph was taken and abutment/crown unit was unscrewed. Adobe Photoshop was used for evaluation and cement remnants were weighed.	Resin-modified glass-ionomer cement.	Undetected excess increased when the margin was located deeper subgingivally (P=0).
Sherif S *et al.* (22)	2011	*In vivo* 5-year period	102 patients with 214 single implant-supported metal-ceramic crowns.	Screw and cement-retained crowns.	Soft tissue and restorative complications were assessed.	Various.	Cement-retained restorations had statistically significantly higher modified plaque score (MPI) and Sulcus Bleeding Index (SMI) (P=0.01).
Wilson TG Jr. (29)	2009	*In vivo* 5-year follow up	39 patients with 20 controlls and 42 tested implants.	Cement-retained crowns.	Implants were tested using a dental endoscope initially.	Various.	Excess dental cement was associated with signs of peri-implant disease 81% of the cases. Clinical and endoscopic signs of peri-implant disease were absent in 74% of the test implants after the removal of excess cement.
Korsch M *et al.* (28)	2013	*In vivo*	71 patients with 126 single implant-supported restorations.	Cement-retained crowns.	The suprastructure and the abutment were removed, investigated and recementated with temporary cement.	Methacrylate cement.	In 59.5% of the implants, cement residues were identified. Bleeding on probing was diagnosed at 80% of the implants with excess cement, suppuration – at 21.3% of the implants. After recementation with Temp Bond, a 76.9% reduction in bleeding on probing was found at follow-up.
Nissan J *et al.* (2)	2011	*In vivo* 15-year follow up	38 patients with 221 single implant-supported metal-ceramic restorations.	Screw and cement-retained crowns.	Soft tissue and restorative complications were assessed.	Temporary cement – Temp Bond.	The mean gingival Index scores (P<0.001) and the mean marginal bone loss (P<0.001) were statistically significantly higher for screw-retained restorations.

of cement-retained restorations are the simplicity of fabrication and lower costs (1, 2, 4, 8, 9, 12, 13, 15). The main advantage of the screw-retained prosthesis is the opportunity to remove it in order to replace it with a new one or to perform oral hygiene procedures without damaging implant abutment (1, 2, 4, 5- 9, 15-17). Removing cement-retained restorations is more difficult without knowing the accurate position of the abutment, and this is the reason why it is usually destroyed with a bur (4, 9, 12, 15). There are some crown fabrication techniques that facilitate removing them when needed – marking an occlusal porcelain-fused-to-metal crown surface (18), using a transverse screw (5), and making the lingual retrieval slot mechanism (12). Digital photographs before and after the cementation are also used (19). If the occlusal surface is not marked, radiographic evaluation can help to identify the position of the abutment (7, 20).

Cement-retained crowns can compensate for the inaccuracy of the implant position (3, 8, 11, 12, 21) and provide better aesthetic appearance (1-3, 6, 9, 11-15) and precision of the restoration (1, 2, 8, 9, 11-15) without the presence of the occlusal screw-access hole which usually takes up about 50% of the occlusal surface (15) and interrupts porcelain integrity (2). In this way, the integrity of the metal framework and the whole crown is achieved. To solve one of the most important disadvantages of the cement-retained prosthesis – difficult retrievability – fabrication of cement-retained crowns with screw-access holes was suggested. da Rocha *et al.* (9) tested 8 cement-retained and 8 cement-retained metal crowns with a screw access channel. They used Universal load-testing machine, untill separation of cemented abutment on the casting and proved that the screw-access hole does not have any influence on better retention when compared to cement-retained crowns with an access hole in the occlusal surface ($P>0.05$). Sherif S *et al.* (22) tested 102 patients with 214 single implant-supported screw- and cement-retained metal-ceramic restorations. They did not find any statistically significant difference in survival between the screw- and cement-retained groups ($P=0.45$). However, Cicciu *et al.* (23) *et al.* made an investigation using the Finite Element Analysis (FEM). This method is designed for measuring compressive loading during the function and its influence on the implant and the surrounding bone. During the investigation, the researchers compared both types of implant systems using biomechanical and engineering techniques and applying the axial force of 400 N. Stress distribution on the occlusal surface was higher on screw-retained crown (22 MPa) than cement-retained crown (10 MPa). Because of the inaccurate occlusal surface (5, 21), functional loading distribution is not tantamount, and the porcelain surrounding the screw-access hole is affected the most, which causes fractures (15). Al-Omari *et al.* (15) compared the resistance of cement-retained restorations, screw-retained restorations, and cement-retained restorations with access holes to ceramic cracks and fractures. The comparison showed that crowns with access holes needed a lesser force to fracture porcelain than crowns without access holes did ($P<0.05$). Nissan *et al.* examined 38 patients with 221 single implant-supported metal-ceramic restorations (2). They proved that porcelain fractures more frequently occurred in screw-retained prostheses ($P<0.001$) (38%+/-0.3%) than in the cement-retained ones (4%+/-0.1%). Loss of the abutment screw was also more common in screw-retained crowns ($P=0.001$) (32%+/-0.3%) than in cement-retained restorations (9%+/-0.2%). Freitas *et al.* (6) analyzed how the implant-crown connection type can influence the implant-abutment-crown strength. 84 implants with metal crowns were tested and showed that cement-retained group presented the higher realiability (0.96) than screw-retained (0.64). Wittneben *et al.* (1) compared the amount of failures in screw- and cement-retained restorations. They identified that the loss of retention and abutment loosening were more characteristic of cement-retained restorations ($P<0.01$), while porcelain fractures were more common in screw-retained crowns ($P=0.02$). Sailer *et al.* (4) noticed that abutment or crown screw loosening more often occurred in screw-retained crowns ($P<0.005$). They concluded that screw-retained crowns were more susceptible to technical failures ($P=0.01$).

Screw-retained prostheses are more advantageous for clinical situations with diminished interocclusal height (2, 5, 9, 11) because adequate retention is more difficult to achieve with cemented crowns. When deciding not to use cement, a prosthodontist can avoid cement extrusion to peri-implant soft tissues or difficult and harmful cement removal procedures (5, 8, 21), which are common in cement-retained prostheses. Sometimes it is difficult to notice and remove residual excess cement, and in these situations it can cause various biological complications or peri-implant soft tissue damage, alveolar bone resorption, and finally – the loss of the implant (1, 4, 9, 13, 15, 24-26). Soft tissue attachment differs between the implant and the tooth (21). Peri-implant tissues do not contain Sharpey fibers that attach the gingiva to the tooth and provide a sufficient barrier. This is the reason why during the seating, the cement is affected by hydraulic pressure and flows in the direction of

the least resistance – i.e. into the peri-implant sulcus. If the cement is not removed, it starts to irritate the peri-implant tissues similarly to the subgingival calculus, which causes inflammatory processes that can result in the loss of the implant (26).

Radiographic investigation is a non-invasive method for detecting the presence of any residual excess cement in peri-implant tissues after crown seating. The success of the investigation depends on the amount and consistency of the cement, marginal integrity, forces involved during the seating, the material and the shape of the abutment, and the localization of the excess cement (24, 27). Wadhwani *et al.* (24) proved that resin cements ("Improve", "RelyX", or "Unicem") can be detected only if their diameter is 2 mm or more, while the resin cement "Premier Implant Cement" is not detectable on radiographic images at all. The most radiopaque cements are those that contain zinc. If the cement is not removed on time, the patient can complain of foul odor in the implant region, suppuration, and presence of fistulas. Clinically, it appears with an increased probing depth and bleeding during probing, and there can also be symptoms of sinusitis. Usually is impossible to control cement extrusion into the peri-implant sulcus even when the abutment margin is located subgingivally.

Linkevičius *et al.* (26) investigated how the position of the abutment margin with respect to the gingiva can influence the amount of the residual excess cement. They used 25 casts with embeeded implant analogs and flexible soft-tissue imitation. Cement-retained metal crowns were cemented on individual abutments with different position of the margin using resin-modified glass-ionomer cement. After cementation and cleaning cement, crowns were removed and evaluated. The investigation showed that when the restoration margins were located deeper subgingivally, the undetected cement quantity was higher (P=0). After two years Linkevičius *et al.* (27) conducted in vivo investigation where 53 patients were treated with 53 single implant-supported cemented metal-ceramic restorations with occlussal hole using resin-modified glass-ionomer cement. After the abutment/crown unit was unscrewed the evaluation was made. Undetected excess increased when the margin was located deeper subgingivally (P=0). Korsch *et al.* (28) examined 126 cement-retained restorations on implants that were cemented using methacrylate cement. In 59.5% of the implants, excess of cement was found, bleeding on probing was diagnosed at 80% of these implants. 76.9% reduction in bleeding on probing was found after removing crowns with abutments and recementated using temporary cement. Wilson TG Jr. (29) endoscopically evaluated 42 implants with positive signs of peri-implantitis. He detected a relationship between residual excess cement and peri-implant soft tissue diseases. Cement was found next to 81% of the implants; 30 days after its removal, the signs of inflammation in peri-implant tissues disappeared in 74% of cases. As mentioned before, Sherif *et al.* (22) examined 102 patients with 214 single implant-supported metal-ceramic restorations and found that the modified plaque index was greater next to cement-retained crowns after 3 (P=0.01) and 60 (P=0.02) months. The sulcus bleeding index was greater next to cement-retained crowns throughout the investigation period – i.e. after 0 (P<0.01), 3 (P=0.01), and 60 (P<0.01) months. Nissan *et al.* (2) compared the amount of failures in both connection types. However, they found that the gingival index and marginal bone resorption were greater next to screw-retained crowns (P<.001).

Wittneben *et al.* (1) concluded that the presence of fistulas and suppuration was more frequently observed next to cement-retained restorations (P=0.02). Sailer *et al.* (4) also found that bone resorption of 2 mm or greater was identified next to cement-retained prostheses (frequency of 2.8%) than next to screw-retained ones (frequency of 0%). However, screw-retained restorations demonstrated more other biological complications – peri-implantitis, fistulas, and mucosal hypertrophy (P<0.005). Another very important factor that influences the status of the peri-implant soft and hard tissues is colonization of bacteria in the microgaps between implant abutment and the crown. If not treated, bacterial infection can cause local inflammation, and finally – the loss of the implant. Recani *et al.* found that the amount of the bacteria (A. actinomycetemcomitans, P. gingivalis, T. forsythia, P. intermedia, T. denticola, and F. nucleatum) did not differ between screw- and cement-retained prostheses (P=0.367) (17).

The lack of high-quality clinical studies makes it difficult to identify which technique is better to use for implants prosthodontics. We need further clinical studies containing more testing groups to evaluate possible complications of screw- and cement retained crowns on implants.

CONCLUSION

From the technical point of view, screw-retained crowns demonstrated more failures such as porcelain cracks and fractures or screw loosening. Cement-retained crowns resulted in more severe biological complications such as peri-implant soft

tissue inflammation and pathological bone resorption. When comparing the condition of peri-implant soft tissues and the surrounding bone next to screw- and cement-retained restorations, the results are more favorable to screw-retained restorations. Screw-retained crowns have such advantages as retrievability, better soft tissue health control and using for limited crown height. Cement-retained restorations provide achieving of better passive fit, aesthetics and precision of occlusal surface that creates more homogenous load distribution during function. Before making the decision concerning what type of connection between the implant and the crown is the best choice, it is very important to evaluate all the benefits of either screw- or cement retained crowns.

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Received: 19 03 2015
Accepted for publishing: 28 06 2017