ORIGINAL RESEARCH

Clinical and Radiological Evaluation of Screw-retained and Cement-retained Single-implant Restorations - A Comparative Study

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ABSTRACT

Background: Single-tooth implant restorations have become an indispensable part of prosthodontic rehabilitation of partially edentulous patients. The prostheses can be secured to implants either with screws or through cementation. There is no consensus on the superiority of one method over the other.

Objective: The present study was an attempt to compare and evaluate screw-retained and cement-retained prostheses for biological and prosthetic complications for a period of 6 months using a split-mouth design.

Materials and Methods: The study was conducted on 14 patients (5 males and 9 females) with bilaterally missing mandibular first molars and the mean age was 28.3 ± 8.827 years (range - 18 and 45 years). Fourteen patients with the mean age of 28.3 ± 8.827 years (range - 18 and 45 years) with bilaterally missing mandibular first molars were selected. Twenty-eight implants were placed one on either side of the arch and on to which either screw- (Group I) or cement-retained (Group II) crowns were given randomly. The patients were evaluated clinically and radiographically for prosthetic and biological complications for 6 months.

Results: There was no statistically significant difference between the mean values of the two groups ($P > 0.05$) with respect to peri-implant marginal bone levels or peri-implant soft-tissue changes during the study period.

Conclusion: There was no evidence that one method of retention was clinically or biologically superior to the other during the 6-month follow-up period. The choice of cement-retained versus screw-retained implant restoration is based on their specific indications for the clinical situation.

Keywords: Cement-retained, Marginal bone level, Peri-implant soft tissue, Peri-implantitis, Screw loosening, Screw-retained, Single-implant restorations.

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INTRODUCTION

Single-tooth implant restorations have become an indispensable part of prosthodontic rehabilitation of partially edentulous patients. The prostheses can be secured to implants either with screws or through cementation.[1,2] The choice of retention in implant-supported prosthetic restorations has an effect on the final occlusal design[3] and is a complex decision involving many points of consideration. The 5-year survival rates of cemented- and screw-retained restorations are 96.03% and 95.55%, respectively.[4] A fastening screw provides the sturdy joint between the restoration and the abutment in screw-retained restorations. The main advantage of screw-retained implant restorations is retrievability, which is convenient in situations such as screw loosening or fracture, hygiene, or modification of the prostheses.[5] Moreover, in clinical situations with reduced interocclusal gap, a screw-retained implant restoration is the natural choice. The major pitfalls of screw-retained restorations are lack of versatility in design and suffer from inherent mechanical complications such as screw loosening and fractures.[6,7] The presence of an occlusal channel for screw access breaks the porcelain continuity[8,9] and diminishes the fracture resistance of the porcelain.[10]

Cement-retained implant restorations use cement (definitive or provisional) for retaining the crown portion to the abutment. Their advantages include good esthetics, good occlusion, simplicity of the technique[11,12] and a more passive fit compared to screw-retained.[13,14] It has also been suggested that the intervening cement film can act as a shock absorber and helps to transfer occlusal load down the crown-abutment-implant system.[15] The main drawbacks of cement-retained restorations are difficulty of retrievability when subsequent prosthetic and peri-implant tissue management are necessary. Moreover, there is a risk for remnant cement

entrapment resulting peri-implant inflammation and marginal bone loss (MBL).[16-19]

The two possible problems that can emerge from the misfit between implant and prosthesis are biological and prosthetic. Biological complications are due to excessive load transfer (to implant-bone interface), peri-implantitis with subsequent bone loss and microbial growth at the microgap between the abutment and the implant.[20,21] The prosthetic complications occur due to abutment screw loosening or fracture[22,23] and ceramic chipping. To date, there have been few randomized split-mouth studies of these two types of implant-supported single tooth restorations. The present study was an attempt to compare and evaluate screw-retained and cement-retained prostheses for biological and prosthetic complications for 6 months of functional loading.

MATERIALS AND METHODS

The study was conducted on 14 patients (5 males and 9 females) with bilaterally missing mandibular first molars and the mean age was 28.3 ± 8.827 years (range - 18 and 45 years). Twenty-eight implants were placed - one on either side of the arch and restored with screw (Group I) as well as cement-retained (Group II) prostheses.

The inclusion criteria were (a) patients with bilateral single edentulous space in mandible having opposing and adjacent teeth [Figure 1 - pre-operative view] and who reported for implant restorations, (b) sufficient bone volume at the implant site, (c) patients with good oral hygiene status as determined by the simplified oral hygiene index.[24] The exclusion criteria included were (a) chronic smokers; (b) patients with severe clenching habit, bruxism, or other parafunctional habits; and (c) patients with systemic diseases. The study was performed in accordance with the principles stated in the Declaration of Helsinki. At the baseline visit, the patients were informed that their data would be used for statistical analysis. Institutional Ethical Committee approval and informed consent were obtained before beginning of the study.

All implants were placed using two-stage surgical technique with the help of a surgical template and standard precautions in health care (WHO 2007) were strictly adhered in all the surgical procedures. In each patient, the edentulous sites (left or right) were randomly selected to receive screw-retained or cemented-retained implant prosthesis. Soft-tissue thickness, bone width, and the bone contour were evaluated by ridge mapping as described by Wilson 1989.[25] Care was taken to preserve 1 mm of buccal and lingual cortical bone for preventing gingival recession in future. All surgical procedures were performed by the same prosthodontist under local anesthesia (2% lignocaine with 1:200000 adrenaline). Both right and left implants (Adin Torague™-S, Adin Implant Systems Ltd.) were placed with cover screws in the first surgical procedure. After a healing period of 4 months, the second-stage surgery was performed. The cover screw was removed and a healing cap was then screwed into place [Figure 2 - healing caps in place]. After 3 weeks, the healing abutment was removed under topical anesthesia and the transfer copings were screwed into the implant. The impression was made with a polyvinyl siloxane material using

Figure 1: Pre-Operative View

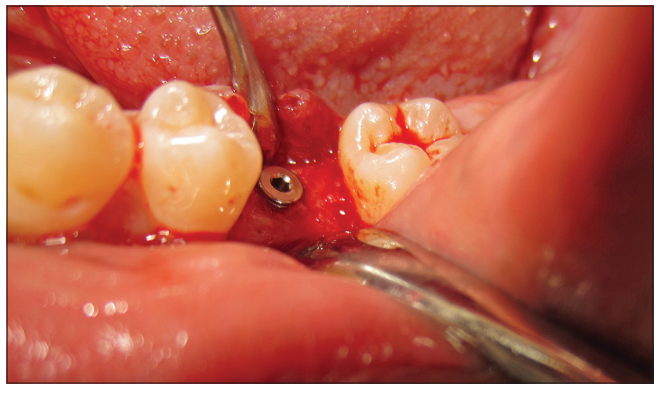

Figure 2: Implant with healing cap

Figure 3: Bilateral Screw-retained & Cement retained Implants

open tray impression technique. The impression was disinfected and an implant analog was positioned over the transfer coping and the cast was poured.

- Group I: A castable plastic abutment (TitanFit™) was used for the fabrication of screw-retained implant crown. The final screw-retained single-implant restoration was tightened into place using torque wrench with an insertion torque of 20 Ncm [Figure 3 - Screw - and Cement-retained implants in place].
- Group II: The straight abutment provided by the manufacturer was modified accordingly and the final prostheses were cemented over the abutment using non-eugenol temporary cement (GC FREEGENOL™) [Figure 3].

In all cases, the abutment screw was retightened after 15 min to counter the embedment relaxation. An intraoral periapical radiograph parallel to the long axis of the implant was taken to assess the fit of the prostheses.

Follow-up Evaluation

A follow-up evaluation program was done for 6 months and the following clinical variables were collected. All patients were educated to understand the relative importance of meticulous oral hygiene to the success of implant-supported restorations.

Assessment of MBL

The marginal bone height was measured in standardized intraoral periapical radiographs taken at 0 (baseline) and 6 months of functional loading. All radiographs were taken using the long-cone paralleling technique (Kodak Ekta speed film) with the film held parallel to the long axis of the implant 9 (Rinn XCP, Dentsply). The radiographs were then digitized with a scanner and stored in JPEG format (300 dpi) on an 8-bit gray-scale. The measurements were performed by means of ImageJ software (National Institute of Health, USA). The distance from the most coronal bone to implant contact to the apex of the implant was measured on the mesial and distal side of the digitized radiograph parallel to the implant axis [Figure 4 - distance measured on radiograph]. The distance was calculated in pixels and calibrated to millimeters with the help of the known length of the implant. Deducting marginal bone level at 6 months from the bone level at 0 months (baseline) of functional loading gave the bone loss in millimeter on mesial and distal aspects of the implant. All measurements were repeated three times and mean was taken.

Peri-implant Soft-tissue Parameters

The peri-implant soft tissue was assessed and recorded in every follow-up visit. Modified plaque index (mPlI) of Mombelli *et al.* 1987[26] was used to assess plaque accumulation and gingival health was recorded using gingival index.[27] Probing pocket depth was measured from the marginal gingiva without the prostheses in place. A traditional periodontal probe was used to record the length from the gingival

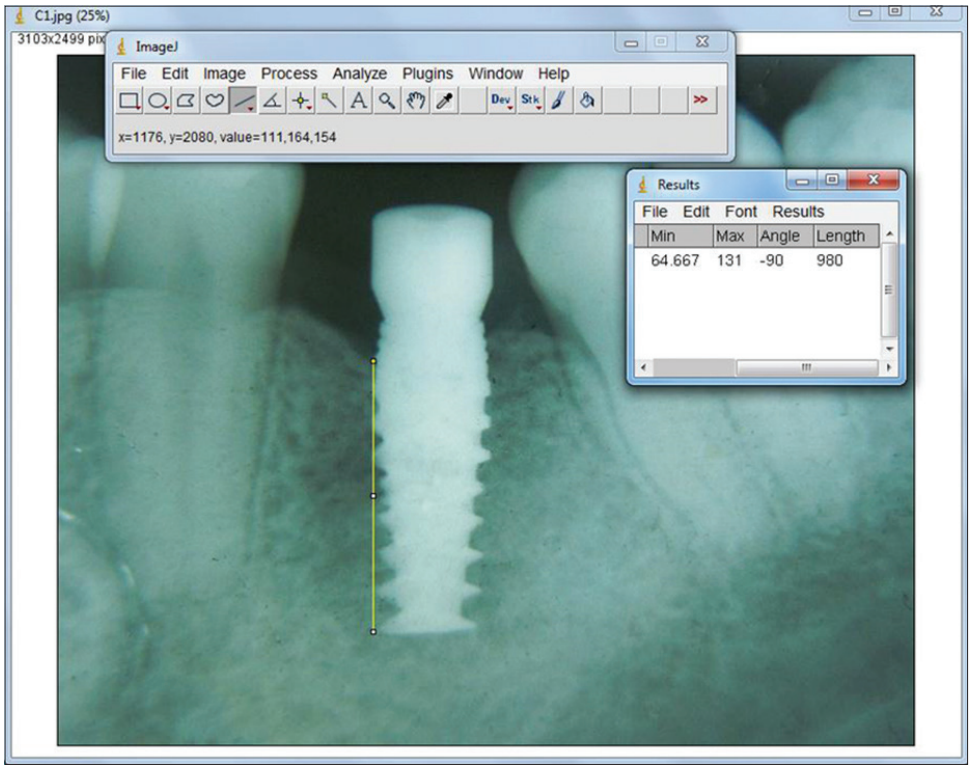

Figure 4: MBL assessment by ImageJ Software

margin to the head of the implant parallel to the long axis of the implant.

Abutment Screw Loosening

The screw loosening was evaluated for two groups using a rating scale in accordance with the California Dental Association's (CDA) quality evaluation system.[28] Screw loosening rated into four rates (R, S, T, and V; from so loosening to extreme, respectively). R and S ratings were considered "satisfactory," while T and V ratings were considered "not acceptable." A brief summary of the CDA rating system used is given in Table 1.

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS), v16.0 (SPSS Inc., Chicago, IL, USA). Data were expressed in its mean, median, and standard deviation and a two-tailed $P < 0.05$ was taken as the level of significance. Parametric bivariate data such as probing depth and bone loss were compared by Student's *t*-test and non-parametric bivariate data such as screw loosening, plaque index, and gingival index were analyzed using Mann–Whitney U-test.

RESULTS

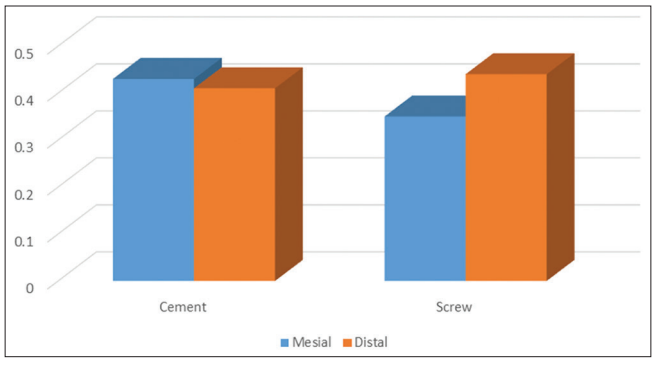

Figure 5: Comparison of marginal bone loss at 6 months

The mean age of the included patients was 28.29 ± 8.827 years (range 18–45 years). The MBL was calculated and compared at 6 months of functional loading for cement-retained and screw-retained single-implant restorations and the results are given in Table 2 and graphical representation in Figure 5. No statistically significant difference could be found between the two groups during the study period. When the two groups were compared for abutment screw loosening and peri-implant soft-tissue parameters, no significant difference could be found between the means [Table 3].

DISCUSSION

The fundamental aim of the present study was whether to select a screw-retained or a cement-retained restoration to provide long-term function of a single-implant restoration. The present study provides results of treatment of 28 implants used for single-tooth implant restorations retained either with screw or cement. The comparison of these two types of restorations with respect to peri-implant marginal bone levels, peri-implant soft-tissue parameters, and screw loosening did not reveal any clinically significant outcome at the end of the evaluation period.

Advantages and Disadvantages of Split-mouth Design

A major advantage of split-mouth study design is the smaller sample size required compared with a parallel-group design. In split-mouth design, each patient acts as his/her own control, resulting in the removal of between-patient variability and increased study power.[29] When all other variables are equal, the sample size for a split-mouth randomized controlled trial (RCT) us approximately half that of a parallel RCT.[30] Carry-across effects and post-randomization bias are likely to invalidate split-mouth trials. If a participant withdraws from the trial, the information from both or all interventions is lost.

Table 1: Modified CDA quality evaluation system for screw loosening

Score	Rating scale	Criteria	
Satisfactory			
0	R "Romeo"	No Loosening	Individual screw is absolutely impossible to tighten manually with a screwdriver
1	S "Sierra"	Slight loosening	Screw is not obviously loose, but it is clearly possible to increase the strain against continuous resistance
Non-satisfactory			
2	T "Tango"	Obvious loosening	Screw can easily be rotated up to half a turn without obvious resistance, but friction can be continuously felt during tightening
3	V "Victor"	Extreme loosening	Screw has to be rotated before reaching friction. No resistance can be felt at applied manual torque

CDA: California Dental Association

Cement-retained versus Screw-retained

Cement-retained implant restorations have the advantages such as better esthetics, good occlusion, simplicity of fabrication, passive framework, and reduced cost of components.[2,17,31] The major pitfall of cement-retained restorations is its irretrievability. Breeding *et al.* suggested that using provisional luting cement, the retrievability can be achieved in cement-retained implants,[19] but provisional cement can resolve over time and microleakage can develop. Definitive cement is not advocated for implant retention, for they are too retentive for retrievability.[32] Wilson *et al.* found that about 81% of the cement-retained implant prostheses with signs of peri-implantitis had residual cement. Wittneben *et al.* 2017 in a systematic review concluded that cement-retained implants restorations are preferred in situations (a) where implants are inclined, (b) short-span prostheses with margins at or above the mucosa level, (c) where an easier control of occlusion is necessary, and (d) prostheses with narrow-diameter crowns.

Screw-retained implant restorations have the major advantage of predictable retrievability. According to Hebel and Gajjar, increased implant survival rates in the last decade have made the once centrally important issue of retrievability less significant.[2] Implant survival/failure and prosthetic failure are two aspects of the dental implant-prosthetic system complications, and both are interrelated, but retrievability is directly related to prosthetic aspect. Screw retention often demands accurate placement of the implant for central location of the screw access hole. The presence of an access opening for screw can weaken the porcelain and can result in unstable occlusal contacts. However, screw-retained implant restorations remain the design of choice in situations with limited intermaxillary clearance (minimum 4 mm).[3,33] They are also indicated for elderly and special needs patients, due to their retrievability[34] and implant-supported provisional restorations because of it.[35]

Sailer *et al.* 2012 reported that MBL >2 mm occurred more frequently at cemented crowns (5-year incidence: 2.8%) than at screw-retained crowns (5-year incidence: 0%), whereas screw-retained restorations exhibited more technical complications.[36] Wittneben *et al.* 2014 in a systematic review found screw-retained prostheses shown fewer technical and biological complications and "loosening of abutment" was more frequent with cemented reconstructions.[4] Millen *et al.* recommended a preference toward screw retention of implant-supported fixed dental prostheses due to the risks associated with cemented prostheses and the limited options for interventions after definitive cementation.[37]

Table 2: Mean marginal bone loss (mm) at 6 months of functional loading

Parameter	Group	Mean±SD		*t* value	*P* value
Mesial	Cement	0.43	0.24	−1.002	>0.05
	Screw	0.35	0.18		
Distal	Cement	0.41	0.18	0.488	>0.05
	Screw	0.44	0.18		

SD: Standard deviation

Biological Complications

Periodontal indices such as plaque index,[38] gingival index[39] and sulcular bleeding index,[39] are not strictly applicable to the peri-implant tissue features. Mombelli *et al.* gave mPlI and modified sulcus bleeding index for peri-implant soft tissue application.[26] Probing depth in relation to implant shoulder is an important and reliable clinical parameter assessed during the follow-up of implant restorations. There is no scientific evidence for the concern that peri-implant probing may endanger implant soft-tissue seal. Successful implants usually show a probing depth of approximately 3 mm.[40] Pocket probing depth ≤5 mm and bleeding on probing were considered as threshold criteria for implant-prosthesis success in some studies.[41]

Screw Loosening

A successful joint between implant and abutment is the most important prerequisite for the appropriate functioning and stability of implant restoration. In all implant-supported restorations, it is preferable to

Table 3: Intergroup comparison of clinical parameters at 6 months of functional loading

Parameter	Group	Mean	Median	±SD	Mann–Whitney U value	*P* value
Screw loosening	Cement	0.79	1.00	0.58	78.5.000	>0.05
	Screw	0.57	0.50	0.65		
Modified plaque index	Cement	1.13	1.00	0.16	62.500	>0.05
	Screw	1.02	1.00	0.07		
Gingival index	Cement	1.13	1.00	0.16	69.000	>0.05
	Screw	1.04	1.00	0.09		
Probing depth	Cement	1.57	1.63	0.28	*t*-value 0.717*	>0.05
	Screw	1.48	1.50	0.25		

SD: Standard deviation

generate axial loading over the prosthetic head of the implant and offset loading may lead to screw loosening and breakage.[42,43] Screw loosening is more likely in single-tooth restorations and can often be related to excessive loading. Moreover, comparing screw loosening in single-tooth implant restorations with long/short span prostheses can be misleading because the biomechanics of occlusal loading are different in both systems. Goodacre *et al.* in a systematic review detected abutment screw loosening in 6% of the prostheses.[44] Palmer *et al.* observed no screw loosing in a 5-year prospective study of Astra single-tooth implants.[45] Priest *et al.* noticed 8% screw loosening in a 10-year-old survival study of single-tooth implant restorations. The screw loosening can lead to screw fracture and dislodgment of the prosthesis. Retightening the screws after 10 min of initial torque application, thereby preventing the settling effect and preload has been advocated.[46,47] Abutment screw loosening can be greatly reduced, if screws are retightened after 10 min.

MBL

MBL around implants could endanger implant life and most implants demonstrate initial bone loss "to the first thread."[48] This "standard MBL" stabilizes at approximately 12 months. Six etiologic factors have been hypothesized for MBL, including surgical trauma, occlusal overload, peri-implantitis, microgap, biologic width, and implant crest module.[49] Immobility, absence of peri-implant radiolucencies, absence of pain, absence of infections, and <0.2mm vertical bone loss per year (after the 1st year) were the criteria put forward by Albrektsson *et al.* evaluate implant success.[50] An implant is considered radiographically successful when MBL was <0.2 mm/year (starting from the 1st year).[51]

In the present split-mouth study, no significant difference could be found with respect to MBL, peri-implant probing depth, mPlI, gingival index, and screw loosening. All patients maintained high level of oral hygiene throughout the study period, probably due to patient education about the importance of longevity of implant-supported restorations and oral hygiene. The choice of retention type (cement- or screw-retained) in single-tooth implant-supported prostheses is based on esthetics, occlusion, inclination of implants, and personal preference and training. The present study is in conformity with Vigolo *et al.* who found no significant differences between the two types of retention with respect to peri-implant marginal bone levels and soft-tissue parameters in a 4-year clinical prospective study. Even though the present study was a longitudinal one, to fully understand the time–space relationships as they affect an individual case, there is a need for comprehensive study using a larger sample and long-term follow-up.

CONCLUSION

The prosthetic and biological complications of screw- and cement-retained implant restorations were studied prospectively for 6 months functional loading period, in 28 single-tooth implant-supported prostheses, in a split-mouth design. The mean age of the samples was 28.3 ± 8.827 years. In all cases, the patients maintained extremely high oral hygiene level and the implants were placed perpendicular to the occlusal place. It can be concluded that no significant differences existed in terms of prosthetic or biological complications between the two groups and there was no evidence suggesting the superiority of any one method of retention.

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