Clinical Performance of Screw- Versus Cement-Retained Fixed Implant-Supported Reconstructions—A Systematic Review

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Purpose: *To assess the survival outcomes and reported complications of screw- and cement-retained fixed reconstructions supported on dental implants.* ***Materials and Methods:*** *A Medline (PubMed), Embase, and Cochrane electronic database search from 2000 to September 2012 using MeSH and free-text terms was conducted. Selected inclusion and exclusion criteria guided the search. All studies were first reviewed by abstract and subsequently by full-text reading by two examiners independently. Data were extracted by two examiners and statistically analyzed using a random effects Poisson regression.* ***Results:*** *From 4,324 abstracts, 321 full-text articles were reviewed. Seventy-three articles were found to qualify for inclusion. Five-year survival rates of 96.03% (95% confidence interval [CI]: 93.85% to 97.43%) and 95.55% (95% CI: 92.96% to 97.19%) were calculated for cemented and screw-retained reconstructions, respectively (*P = .69*). Comparison of cement and screw retention showed no difference when grouped as single crowns (I-SC) (*P = .10*) or fixed partial dentures (I-FDP) (*P = .49*). The 5-year survival rate for screw-retained full-arch reconstructions was 96.71% (95% CI: 93.66% to 98.31). All-ceramic reconstruction material exhibited a significantly higher failure rate than porcelain-fused-to-metal (PFM) in cemented reconstructions (*P = .01*) but not when comparing screw-retained reconstructions (*P = .66*). Technical and biologic complications demonstrating a statistically significant difference included loss of retention (*P ≤ .01*), abutment loosening (*P ≤ .01*), porcelain fracture and/or chipping (*P = .02*), presence of fistula/suppuration (*P ≤ .001*), total technical events (*P = .03*), and total biologic events (*P = .02*).* ***Conclusions:*** *Although no statistical difference was found between cement- and screw-retained reconstructions for survival or failure rates, screw-retained reconstructions exhibited fewer technical and biologic complications overall. There were no statistically significant differences between the failure rates of the different reconstruction types (I-SCs, I-FDPs, full-arch I-FDPs) or abutment materials (titanium, gold, ceramic). The failure rate of cemented reconstructions was not influenced by the choice of a specific cement, though cement type did influence loss of retention.* Int J Oral Maxillofac Implants 2014;29(Suppl):84–98. doi: 10.11607/jomi.2014suppl.g2.1

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Implant-supported reconstructions are well-established treatment options and have evolved to a standard of care in dental medicine. The possibilities and expectations of achieving a successful, functional, and stable treatment outcome have increased with the evolution of implant surfaces and designs, prosthetic components, clinical techniques, and dental materials. One of the important decisions in implant prosthodontics is the choice of the connection type of the final restoration to the implant via the screw-retained abutment. The restorative connection can be either screw- or cement-retained. With screw-retained restorations, an abutment or a mesostructure may be separate to the restoration (two-piece) or combined as part of the fabrication procedure (one-piece). In general, both retention types have their advantages and limitations.[1–5]

Despite patients showing no preference for either retention system,[6] there are relevant clinical and technical issues. These include ease of fabrication,

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precision, passivity of the framework, retention provided by cement and abutment, occlusion, esthetics, accessibility, retrievability, complications, and cost. These are not easily examined objectively together, and to single out the effect of a specific factor seems to be very demanding. A previous systematic review has focused on implant and prosthesis survival, finding no statistically significant differences between screw and cement retention.[7] In vitro and animal studies have been conducted to more closely examine technical and biologic complications in screw- and cement-retained prostheses.[8–10] While these may give useful information to help design future human trials, this information cannot routinely be related to a clinical situation.

The survival rates of implant-supported reconstructions and the associated technical complication rates have been well established. Implant-supported single crowns (I-SC), fixed partial dentures (I-FDP), and I-FDPs with cantilever extensions demonstrate survival rates of 94.5%, 95.2%, and 94.3% at 5 years, respectively.[11–13] The prevalence of technical complications is higher for implant reconstructions compared to those on teeth,[12] and the most commonly reported technical complications are veneer fracture, screw loosening, and loss of retention.[11–13] With respect to biologic complications, peri-implantitis and bone loss are reported to have the highest prevalence.[11,14] Although these figures are now commonly cited, they have not been attributed to screw or cement retention.

A recent and comprehensive systematic review on this subject was presented at the European Association of Osseointegration Consensus Conference 2012.[15] This review focused on implant and reconstruction survival, reporting estimated rates for 5 and 10 years, as well as technical and biologic complications in studies with a mean follow-up of at least 1 year. The authors grouped the event rate data by cement- or screw-retained single crowns, I-FDPs, and full arch I-FDPs. No statistically significant differences were reported for restoration survival. Estimated biologic complication rates (bone loss > 2 mm) were found to be higher in cemented reconstructions, whereas screw-retained reconstructions exhibited more technical complications. Based on their improved retrievability, the screw-retained reconstructions were given preference.

The objective of the present review was to retrieve a detailed data pool from published clinical studies on biologic and technical failure and complication rates observed with cement- and screw-retained fixed implant-supported reconstructions. The aim was also to associate the observed differences in the estimated event risks with a list of additional prosthetic characteristics such as type of reconstruction, material of the supra-structure (restorative and abutment material), and cement type.

MATERIALS AND METHODS

A PICO (population, intervention, comparison, and outcome) question was agreed upon between the authors. This question asked what the clinical performance (including complications and failures) of implant-supported reconstructions was in patients with edentulous sites treated with either screw or cement retention.

Systematic Search Design and Strategy

An electronic search of publications from 2000 to September 2012 was established using three electronic databases: EMBASE, Medline (via PubMed), and the Cochrane Library. The search included peer-reviewed publications in the English, German, and French languages. MeSH and free-text terms were used in the search and included the terms listed in Table 1.

The search was then narrowed by exclusion of non-dental studies by adding the terms "dental" OR "dentist*" OR "tooth" OR "teeth." All articles were selected by well-defined inclusion and exclusion criteria (Table 1).

The inclusion criteria included study designs of randomized controlled trials (RCTs), clinical trials, prospective studies, and retrospective cohort studies. Patients in the studies had to have been followed clinically for the observation period. Studies using telephone interviews or patient records were not included.

Other inclusion criteria for study selection were studies with:

- A mean follow-up time of at least 3 years
- A minimum number of 10 patients
- A report of the restoration retention used (screw or cement)
- Implant-supported fixed reconstructions
- English, German, or French language

Case reports, animal studies, in vitro studies, abstracts, and letters were excluded from review. Studies with a mean follow-up of < 3 years; not reporting on retention type; not written in English, German, or French; or examining removable prostheses were also excluded from the review. Data from patient cohorts used for repeated publications were limited to the most recent version.

The selection strategy of the articles is outlined in Fig 1. Following the electronic search, titles and abstracts were screened by two independent reviewers (JW, UB) to assess their suitability for inclusion in the review. Following discussion, a consensus was reached regarding disputed articles. Subsequently, a full-text search was performed by two reviewers (JW, CM). In addition, a manual search (CM) was conducted of the bibliographies of recently published relevant reviews.

Table 1 Systematic Search Strategy

Focus question	What is the clinical performance of implant-supported reconstructions (including complications and failures) in patients with edentulous sites treated with either screw or cement retention?
Search strategy	
Population	#1 (implant*) OR (full arch) OR (cross arch) OR (crossarch) OR (abutment) OR (dental abutments [MeSHTerms]) OR (dental arch [MeSH Terms]) OR (dental implants [MeSH Terms])
Intervention or exposure	#2 (implant supported prosthesis) (Dental Prosthesis, Implant supported [MeSH Terms])OR (insertion) OR (crown [MeSH Terms]) OR (fixed partial dentures) OR (denture, Partial, Fixed [MeSH Terms]) OR (FPD) OR (FDP) OR (bridge) OR (reconstruct*) OR (passive fit) OR (crown margin) OR (marginal adapation[MeSH Terms]) OR (interface*) OR (implant bridge) OR (laborator*) OR (friction[MeSH Terms]) OR (clamping force) OR (fixture) OR (insert lodges) OR (suprastructure)
Comparison	#3 (screw*) OR (cement*) OR (retain*) OR (retention*) OR (fixation) OR (transvers*) OR (retrievab*) OR (torque) OR (transfer) OR (access hole) OR (torque wrench) OR (retrieval) OR (tight*) OR (transocclusal) OR (Bone Screws [MeSH Terms]) OR (dental cements [MeSH Terms]) OR (dental prosthesis retention[MeSH Terms]) OR (denture retention [MeSH Terms]) OR (cementation[MeSH Terms]) OR (torque[MeSH Terms]) OR (seat*)
Outcome	#4 (loss of retention) OR (precision) OR (fit) OR (seal) OR (loosening) OR (fracture) OR (fatigue) OR (leakage) OR (gap) OR (cement rest) OR (deformation) OR (cement dissolution) OR (survival) OR (complicat*) OR (risk) OR (success) OR (rate) OR (failure) OR (prosthesis failure [MeSH Terms]) OR (dental leakage[MeSH Terms]) OR (treatment outcome[MeSH Terms]) OR (dental restoration failure[MeSH Terms])
Search combination	#1 AND #2 AND #3 AND #4
Database search	
Language	English, German, and French
Electronic	EMBASE, Medline (via PubMed), and Cochrane Library
Selection criteria	
Inclusion criteria	RCTs Clinical trials Prospective studies Retrospective studies with patient recall (clinical examination) Written in English, German, or French Minimum follow-up time of 3 y Report of retention type Studies including implant supported fixed reconstructions (single crowns or FDPs) Report of clinical performance (including complications and failure) of fixed implant-supported reconstructions
Exclusion criteria	Not written in English, German, or French Minimum follow-up time < 3 y Studies that were based on patients' charts Case reports Animal studies In vitro studies No report on retention type No report on clinical performance of implant-supported reconstructions Studies on removable reconstructions

The manual search included articles that were published prior to the year 2000.

Data of each individual study were extracted by two authors (CM, JW) and broken down on an Excel (Microsoft) spreadsheet by: author, year, type of study (prospective/retrospective), planned number of patients, actual number of patients, mean age patient, age range patient, study setting (university/private practice), location (anterior/posterior), restoration type, abutment material, restoration material, retention type, cement type, implant brand, implant types, and total implant number. The total exposure time of the reconstructions was calculated, and survival of the restorations was defined as remaining in situ throughout the study period.

Data regarding technical complications were also extracted, including loss of retention, loosening of the occlusal/abutment screws, loss of screw access filling, fracture and/or chipping of the veneer, fracture of the implant/abutment/framework/screw, and any other complications.

The data for biologic complications included bone loss > 2 mm, peri-implantitis, peri-implant mucositis, general soft tissue complications (including fistula-swelling), recession, loss of the implant, any esthetic complication, and any other reported complications.

Statistical Analysis

Failure and complication rates of single studies were calculated by dividing the number of events by the total exposure time of the I-FDPs. Estimated failure rates, event rates, and 95% confidence intervals (CI) were calculated by assuming Poisson distributed number of events. Random effects Poisson regression was used when several studies were summarized.

Five- and 10-year survival rates were calculated through the relationship between event rate and the survival function S by assuming constant event rates as follows:

$$S(T) = \exp(-T \times \text{event rate})$$

All statistical analysis was performed using Stata 11.2. Significance level was set at $P = .05$.

The estimated event rate per 100 years was calculated using the observation time of the studies together with the number of reconstructions observed (eg, 100 reconstructions observed for 1 year each, with only one failure, would have an event rate of 1 per 100 years).

Comparisons included differences in event rates per 100 reconstruction years between cemented and screw-retained reconstructions in total and when grouped according to reconstruction type, reconstruction material, and abutment material. The compared events were failures, single technical and biologic complications, and combined (total) technical and combined (total) biologic complications.

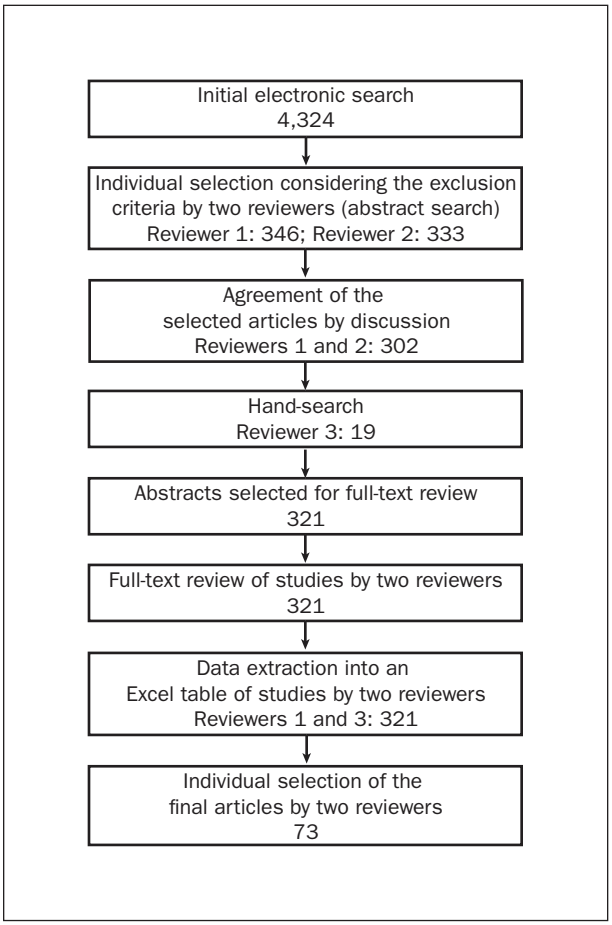

Fig 1 Flow diagram describing the search design and strategy.

RESULTS

The titles and abstracts of 4,324 articles (initial search) were screened independently by two authors (JW, UB) to assess their suitability for inclusion in the review (Fig 1). Following discussion, a consensus was reached regarding disputed articles. There were 302 full-text articles obtained for screening. In addition, a further 19 articles were obtained from a manual search of the bibliographies of review articles identified within the initial search and recently published relevant reviews. Two authors (JW, CM) independently reviewed the 321 articles. Of these full-text articles, 73 were found to qualify for inclusion in the review.

The study designs of these articles were: 52 prospective cohort studies (71.2%), 13 retrospective (17.8%), 2 split-mouth design, and 6 RCT (8.3%) (Table 2). Most studies were carried out in a university setting (63%) (Table 3).

Table 2 Study Designs

	Studies	%
Prospective cohort	52	71.2
Retrospective cohort	13	17.8
Split mouth	2	2.7
RCT	6	8.3
Total	73	100

Table 3 Study Settings

	Studies	%
Private practice	13	17.8
University	46	63.0
Specialist clinic	6	8.2
Multicenter	6	8.2
Not reported	2	2.8
Total	73	100

Failures

A total of 5,858 fixed implant reconstructions were analyzed with a mean exposure time of 5.40 years.

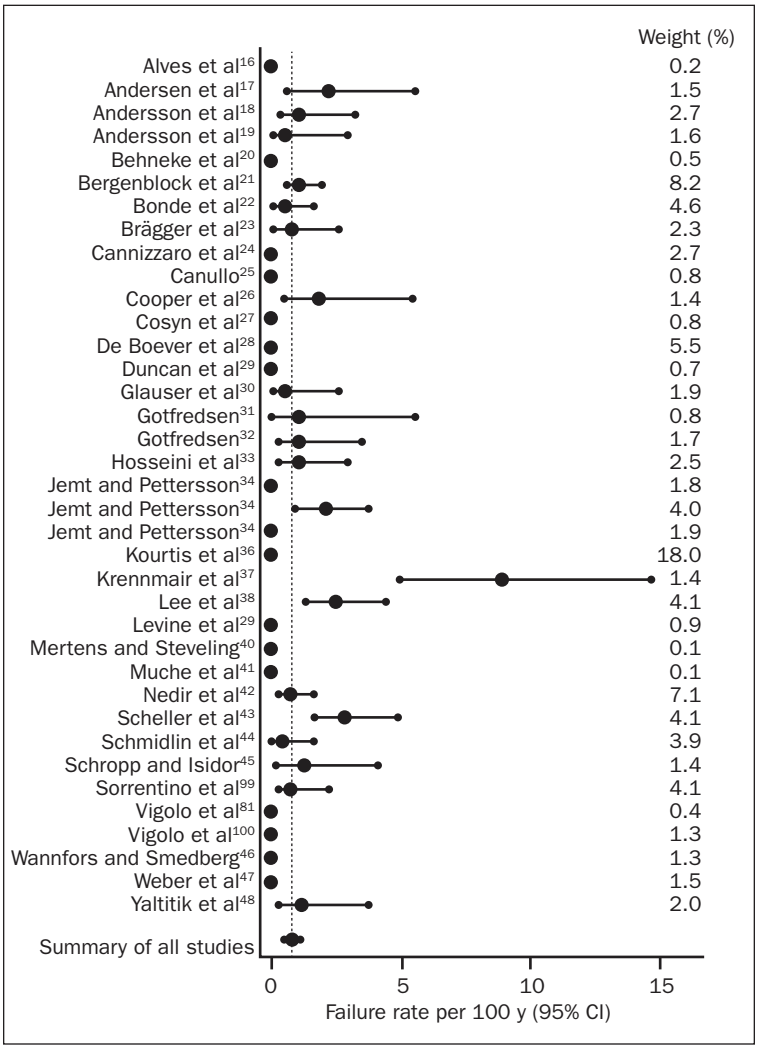

Fig 2 Failure rate and weight of all included studies on cement-retained reconstructions (n = 37).

Of these 3,471 (59%) were screw-retained and 2,387 (41%) were cement-retained. The failure rates and weighting of each study are shown in Figs 2 and 3. Based on a random-effects Poisson regression analysis, overall 5-year survival rates of 96.03% (95% CI: 93.85% to 97.43%) and 95.55% (95% CI: 92.96% to 97.19%) were calculated for cement- and screw-retained reconstructions, respectively. Ten-year survival rates were also estimated and revealed survival rates of 92.22% (95% CI: 88.07% to 94.93%) and 91.30% (95% CI: 86.42% to 94.46%) for cement- and screw-retained reconstructions, respectively. Overall estimated failure rates of 0.81 (95% CI: 0.52 to 1.27) and 0.91 (95% CI: 0.57 to 1.46) per 100 restoration years were calculated for cement- and screw-retained reconstructions, respectively. This difference was not statistically significant ($P = .69$) (Table 4). However the estimated failure rate of two-piece screw-retained reconstructions (0.45 [95% CI: 0.32 to 0.64]) was significantly different compared to the cemented types ($P = .00$).

Of the 5,858 reconstructions, 1,720 were I-SC, 979 were I-FDP, 928 were full-arch reconstructions, and 61 were cantilever I-FDPs (Table 5). In some studies, several types of reconstructions were used and not reported separately in the article. These data have therefore been used for the calculation of the overall reconstruction failure and survival rate of screw versus cement retention but have not been included in the separate reconstruction groups.

Failures by Reconstruction Type

Single Crowns (I-SC). A total of 25 studies reported on cemented and 9 on screw-retained single crowns (I-SC) with a mean follow-up time of 4.92 years. A total of 1,720 SCs were analyzed; 1,316 were cemented and 404 screw-retained. The failure rate of the cemented I-SCs (0.74 [95% CI: 0.44 to 1.24]) was not significantly different from the screw-retained I-SCs (1.85 [95% CI: 0.65 to 5.29]) ($P = .10$) (Table 6). The 5-year survival rate was 96.37% (95% CI: 93.99 to 97.82) for cement- and 91.16% (95% CI: 76.76 to 96.80) for screw-retained single crowns (Table 7).

Fixed Partial Dentures (I-FDP) and Cantilever I-FDP. A total of 19 studies (5 on cemented and 14 on screw-retained) with a mean follow-up time of 5.73 years reported on a total of 1,040 I-FDPs (including cantilever I-FDPs) showing no significant difference between cement (1.11 [95% CI: 0.40 to 3.07]) and screw retention (1.78 [95% CI: 0.59 to 5.34]) ($P = .49$) (Table 6). The 5-year survival rate was 94.60% (95% CI: 85.77% to 98.02%) for cemented and 91.48% (95% CI: 76.57% to 97.09%) for screw-retained I-FDPs (Table 7).

Full-Arch Reconstructions. A total of 22 studies (1 on cemented and 21 on screw-retained) with a mean follow-up time of 7.46 years (Table 6) were obtained. The failure rate was estimated at 0.67 per 100 reconstruction years and the 5-year survival rate was 96.71% (95% CI: 93.66% to 98.31%) (Table 7). Further analysis was not possible due to the low number of studies with cement-retained full-arch reconstructions.

Failures by Material Type

Abutment Material. There was no significant difference between the failure rates of screw-retained reconstructions on either titanium, gold, or ceramic abutments. Neither cemented nor screw-retained reconstructions exhibited a statistically

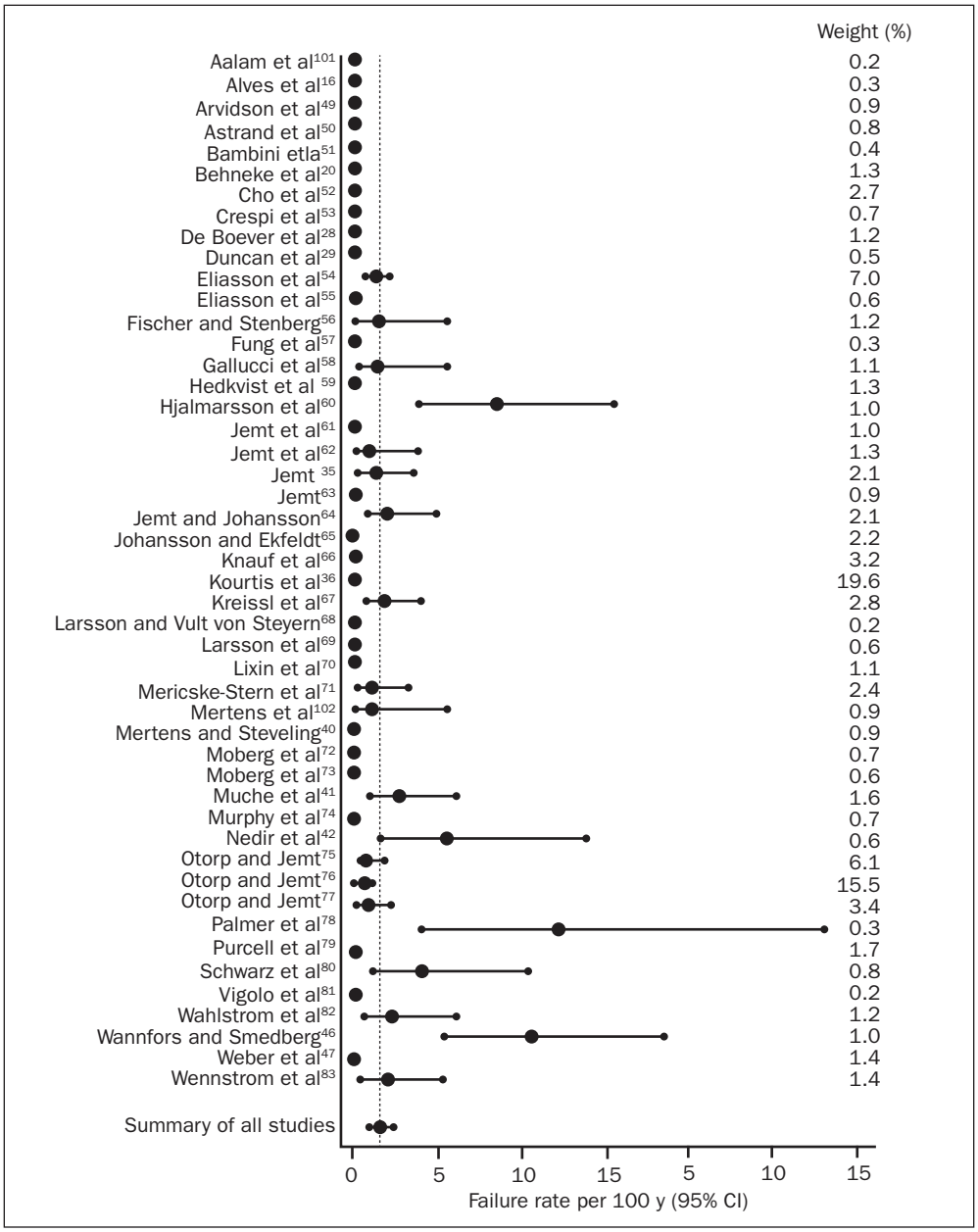

Fig 3 Failure rate and weight of all included studies on screw-retained reconstructions (n = 48).

Table 4 Overall Estimated Failure Rates

Studies	Retention type	Reconstructions	Exposure time (y)	No. of failures	Estimated failure rate per 100 y (95% CI)	*P* value
37	Cement	2,387	11861	102	0.81 (0.52 – 1.27)	
48	Screw	3,471	19799	99	0.91 (0.57 – 1.46)	.69
7	One-piece screw	276	1327	23	2.08 (0.47 – 9.27)	.08*
14	Two-piece screw	932	7481	34	0.45 (0.32 – 0.64)	.00*

*Compared with the estimated event rate of cement reconstructions.

significant difference between material types ($P = .09$ and $P = .06$ for cement and screw, respectively). These results are reported in Table 8.

Prosthetic Material. The use of all-ceramic material exhibited a significantly higher failure rate (0.88 [95% CI: 0.58 to 1.33]) than porcelain-fused-to-metal (PFM)

Table 5 Type of Reconstructions

Reported restoration	Reconstructions	%
I-SC	1,720	29.4
I-FDP	979	16.7
Full-arch	928	15.8
I-SC and full-arch	123	2.1
I-SC and I-FDP	461	7.9
Cantilever I-FDP	61	1.0
I-FDP and full-arch	56	1.0
I-SC, I-FDP, and cantilever	168	2.9
I-SC, I-FDP, full-arch, cantilever	1,308	22.3
Not reported	54	0.9
Total	5,858	100

(0.37 [95% CI: 0.22 to 0.61]) in cemented reconstructions ($P = .01$), whereas there was no significant difference in the failure rates when comparing screw-retained reconstructions fabricated with different materials ($P = .66$) (Table 9).

Cement Material. When examining the differences between failure rates for the cement types (phosphates, glass ionomers, resins and eugenol-based cements), no statistically significant difference was found ($P = .37$) (Table 10).

Complications

The data extraction of the included studies only allowed a statistical analysis if the complications were presented in the study. Where the data was not complete, the statistical analysis was not performed. Therefore, the number of studies and reconstructions varies among the complication types, and this information is listed in Table 11.

Technical Complications. Complications demonstrating a statistically significant difference between cement- and screw-retained reconstructions include loss of retention, abutment loosening, and porcelain fracture and/or chipping, as well as the total events.

The other complications including fracture of abutment, fracture of framework, fracture of implant, screw fracture, and resin chipping and/or fracture did not demonstrate statistical significance. The complications loss of cover of access hole and loosening of occlusal screw could not be compared, as they were only available for screw-retained reconstructions. Here, event rates of 1.76 per 100 reconstruction years could be calculated for loosening of occlusal screw and 0.81 for loss of cover of access hole. A full summary of the data related to technical complications is given in Table 11.

A comparison between loss of retention and cement type was carried out and showed a statistically significant difference between cement type and loss of retention ($P \leq .01$). The estimated event rates per 100 years are outlined in Table 12.

When assessing the overall technical complications between cement- and screw-retained reconstructions, the resin chipping category was removed due to the fact that no further analysis was possible on this category. This comparison of the total events demonstrated a significant difference ($P = .03$) (Table 11). However comparing one- and two-piece screw-retained reconstructions to the cemented ones demonstrated no significant difference (Table 11).

Biologic Complications. When comparing the event rates of biologic complications between screw- and cement-retained reconstructions, only the category for presence of fistula/suppuration demonstrated statistical significance, indicating a higher event rate with cement retention (1.65 [95% CI: 0.55 to 4.96]) ($P \leq .01$). Outcomes of the other event rates of bone loss (> 2 mm), peri-implantitis, presence of fistula/suppuration, peri-implant mucositis, and recession were not statistically significant among the two retention systems.

The summary of the total biological complications as shown in Table 13 shows a statistically significant result ($P = .02$). One- and two-piece screw- retained reconstructions presented no significant difference in comparison to cemented ones (Table 13).

DISCUSSION

The fabrication of an implant-supported reconstruction includes many clinical and laboratory processes and a series of decisions related to the use of implant components, materials, etc. At some point during the treatment planning stage, the treating clinician and the technician must select the method of retention, screw or cement. Both of these methods have their advantages and limitations, and it is therefore the clinician's responsibility to select the most appropriate method of retention for the individual patient.[5]

Screw-retained implant reconstructions have the advantages of predictable retrievability; require a minimal amount of interocclusal space; and are easier to remove when hygiene maintenance, repairs, or surgical interventions are required. Screw-retained implant reconstructions require precise, prosthetically driven placement of the implant due to the position of the screw access hole. The manufacturing process of screw-retained reconstructions is more technique sensitive and more demanding when compared to cement-retained reconstructions.[4]

The construction of cemented restorations is not as technically demanding as screw-retained restorations and therefore they are less cost-intensive to produce.

Table 6 Characteristics and Estimated Failure Rates of Reconstructions

Restoration type	Studies	Retention type	Reconstructions	Exposure time (y)	Failures	Estimated failure rate per 100 y (95% CI)	*P* value
I-SC	25	Cement	1,316	6,695	65	0.74 (0.44–1.24)	.10
	9	Screw	404	1,761	17	1.85 (0.65–5.29)	
I-FDP	5	Cement	309	1,343	23	1.11 (0.40–3.07)	.49
	14	Screw	731	4,618	35	1.78 (0.59–5.34)	
Full-arch	1	Cement	6	18	0	0 (—)	—
	21	Screw	922	6,905	39	0.67 (0.34–1.31)	

Table 7 Estimated Failure and Survival Rates

Restoration	Retention type	Failure rate	5-year survival	10-year survival
All	Cement	0.81 (0.52–1.27)	96.03 (93.85–97.43)	92.22 (88.07–94.93)
	Screw	0.91 (0.57–1.46)	95.55 (92.96–97.19)	91.30 (86.42–94.46)
I-SC	Cement	0.74 (0.44–1.24)	96.37 (93.99–97.82)	92.87 (88.34–95.70)
	Screw	1.85 (0.65–5.29)	91.16 (76.76–96.80)	83.11 (58.92–93.71)
I-FDP	Cement	1.11 (0.40–3.07)	94.60 (85.77–98.02)	89.49 (73.57–96.08)
	Screw	1.78 (0.59–5.34)	91.48 (76.57–97.09)	83.69 (58.63–94.27)
Full-arch	Cement	0 (—)	—	—
	Screw	0.67 (0.34–1.31)	96.71 (93.66–98.31)	93.52 (87.72–96.66)

Table 8 Abutment Material - Exposure Time and Estimated Failure Rate of Reconstructions

Retention	Studies	Abutment type	Reconstructions	Exposure time (y)	Failures	Estimated failure rate per 100 y (95% CI)	*P* value
Cement	4	Titanium	98	474	3	0.57 (0.12–2.72)	
	6	Gold	280	1,213	4	0.33 (0.04–2.59)	.09
	10	Ceramic	617	4,128	70	1.97 (0.97–3.99)	
Screw	12	Titanium	560	3,041	13	0.39 (0.16–0.97)	
	11	Gold	637	2,804	33	1.50 (0.66–3.42)	.06
	4	Ceramic	239	1,925	9	0.38 (0.09–1.57)	

Table 9 Material of Reconstructions

Retention	Studies	Material	Reconstructions	Exposure time (y)	Failures	Estimated failure rate per 100 y (95% CI)	*P* value
Cement	17	PFM	876	4,058	15	0.37 (0.22–0.61)	
	0	Acrylic	—	—		—	.01
	6	Ceramic	333	2,513	22	0.88 (0.58–1.33)	
Screw	17	PFM	868	3,420	23	0.74 (0.32–1.68)	
	14	Acrylic	741	6,113	26	0.42 (0.17–1.01)	.66
	2	Ceramic	35	155	0	0 (—)	

Table 10 Failure of Reconstructions by Cement Type

Studies	Cement type	Reconstructions	Exposure time (y)	Failures	Estimated failure rate per 100 y (95% CI)	*P* value
5	Phosphate	414	2,935	29	0.95 (0.33–2.75)	
4	GI	151	1,063	9	0.85 (0.47–1.51)	.37
3	Resin	238	1,241	4	0.32 (0.06–1.65)	
5	ZOE	226	790	15	1.90 (0.30–12.15)	

Table 11 Technical Complications

Complication	Retention type	Studies	Reconstructions	Exposure time (y)	Events	Estimated event rate per 100 y (95% CI)	*P* value
Loss of retention	Cement	30	2,015	10,394	95	5.44 (2.14–13.82)	< .01
	Screw	36	2,741	15,402	77	0.61 (0.30–1.25)	
Loss of cover of access hole	Cement	—	—	—	—	—	
	Screw	32	2,534	14,744	131	0.81 (0.33–1.99)	
Fracture and/or chipping of ceramic	Cement	31	1,958	10,063	30	1.02 (0.37–2.83)	.02
	Screw	37	3,001	17,428	212	3.56 (1.95–6.49)	
Loosening of occlusal screw	Cement	—	—	—	—	—	
	Screw	39	3,023	17,031	201	1.76 (0.98–3.19)	
Loosening of abutment	Cement	31	1,958	10,063	86	2.31 (1.09–4.89)	< .01
	Screw	36	2,786	15,970	85	0.62 (0.33–1.17)	
Fracture of abutment	Cement	31	1,958	10,063	4	0.04 (0.01–0.20)	.52
	Screw	34	2,611	14,459	20	0.07 (0.03–0.18)	
Fracture of framework	Cement	2	125	569	14	2.46 (1.63–3.72)	.35
	Screw	37	2,976	16,727	59	0.28 (0.11–0.71)	
Fracture of implant	Cement	31	1,958	10,063	2	0.02 (0.00–0.15)	.27
	Screw	37	2,893	16,291	11	0.16 (0.03–0.79)	
Screw fracture	Cement	31	1,958	10,063	10	0.10 (0.02–0.49)	.85
	Screw	39	3,125	18,051	47	0.20 (0.09–0.44)	
Resin chipping and/or fracture	Cement	1	28	84	0	0 (—)	—
	Screw	35	2,757	15,846	539	4.40 (1.50–12.88)	
Other	Cement	29	1,790	8,903	33	2.29 (0.74–7.11)	.52
	Screw	39	2,980	17,518	243	1.73 (0.77–3.89)	
Summary (all except resin chipping)	Cement	33	2,078	10,778	274	9.81 (6.60–14.60)	.03
	Screw	42	3,226	18,480	1,086	7.50 (5.37–10.47)	
	One-piece screw	6	236	1,127	83	9.47 (4.83–18.59)	.93*
	Two-piece screw	12	857	7,052	394	6.27 (3.35–11.74)	.166*

*Compared with the estimated event rate of cement reconstructions.

Table 12 Cement Type and Loss of Retention

Studies	Cement type	Reconstructions	Exposure time (y)	Events	Estimated event rate per 100 y (95% CI)	*P* value
4	Phosphate	183	2,089	0	0 (—)	< .01
4	GI	151	1,063	8	1.04 (0.22–4.98)	
2	Resin	208	1,141	20	1.75 (0.52–5.95)	
5	ZOE	226	790	5	0.72 (0.15–3.41)	

Other advantages of this retention type include compensation of implant position discrepancies, passivity of fit, improved esthetics, and easier control of occlusion.[2,4,84] A major problem of cement retention is the difficulty of removing excess cement,[85,86] which has been associated with the development of peri-implant diseases such as peri-implant mucositis and peri-implantitis.[84,87]

A considerable emphasis can be seen in the dental literature concerning screw versus cement retention. Several conventional and systematic reviews have already been published exploring the advantages and disadvantages of cement- versus screw-retained implant-supported reconstructions,[5,7,15,88–90] leaving the clinician with conflicting information.

There are a large variety of methods to connect a restoration to the implant other than just cement or screw retention. An attempt to address this problem was made in this review by attempting to differentiate between one- and two-piece screw-retained restorations. Unfortunately, however, the number of studies that accurately reported the method of restoration at-

Table 13 Biologic Complications Summary

Complication	Retention type	Studies	Reconstructions	Exposure time (y)	Events	Estimated event rate per 100 y (95% CI)	*P* value
Bone loss (> 2 mm)	Cement	27	1,780	9,497	39	0.81 (0.29–2.24)	.07
	Screw	32	2,632	15,415	470	2.09 (1.11–3.93)	
Peri-implantitis	Cement	26	1,691	8,059	46	0.54 (0.22–1.31)	.16
	Screw	29	2,549	15,112	48	0.36 (0.15–0.86)	
Presence of fistula, suppuration	Cement	27	1,713	9,102	55	1.65 (0.55–4.96)	< .01
	Screw	30	2,567	15,292	36	0.22 (0.10–0.52)	
PI mucositis	Cement	24	1,612	7,237	60	1.38 (0.60–3.17)	.75
	Screw	29	2,496	14,881	167	1.61 (0.71–3.64)	
Recession	Cement	24	1,527	7,143	6	0.12 (0.03–0.47)	.19
	Screw	28	2,365	13,737	1	0.01 (0.00–0.06)	
Any esthetic complication	Cement	27	1,786	8,969	17	0.20 (0.08–0.54)	.69
	Screw	29	2,613	16,144	24	0.24 (0.09–0.63)	
Other	Cement	27	1,811	9,429	45	1.44 (0.49–4.28)	.87
	Screw	31	2,731	16,498	207	1.31 (0.67–2.59)	
Summary	Cement	29	1,864	9,749	268	7.01 (4.66–10.55)	.02
	Screw	33	2,778	16,802	953	4.81 (3.43–6.76)	
	One Piece screw	4	114	617	39	4.87 (1.52–15.63)	.54*
	Two Piece screw	11	842	7,028	705	10.51 (5.89–18.74)	.17*

*Compared with the estimated event rate of cement reconstructions.

tachment was few and thus the results of the one- and two-piece were not further analyzed. The estimated failure rates of one- and two-piece screw-retained reconstructions were calculated and compared to the cemented ones. Studies including restorations that demonstrated a mix of types by being cemented extraorally prior to being screw-retained were excluded from this review. Analysis of further retention types was not possible due to the low numbers reported.

The present systematic review was initiated to compare failure and complication rates not only based on the type of retention but also considering additional prosthetic and material aspects and hopefully to gather new arguments to support one or the other retention type.

Failures

The estimated failure rates of the pooled cemented and the pooled screw-retained reconstructions were similar to what has been reported in other systematic reviews on implant-supported reconstructions.[11,12,15,91] In a previous systematic review by Weber and Sukotjo,[7] the prosthetic success rates of screw- and cement-retained implant-supported reconstructions were reported at the most recent examination (> 72 months) as 93.2% for cemented and 83.4% for screw-retained restorations ($P > .05$). It should be noted that this study reported on success rates and not survival as in the present review.

Failures were more frequently observed with screw-retained crowns compared to cemented single crowns. The survival rate at 5 years for screw-retained I-SC was comparably lower than that for cemented I-SCs. However, this comparison lacked statistical significance, which was in agreement with a recent review by Sailer et al.[15]

Cement- or screw-retained I-FDPs (including cantilever I-FDPs) showed no statistical differences in survival rates between the retention systems. Similar survival rates were published by Pjetursson et al[14] in a systematic review evaluating implant-supported I-FDPs (survival rates, 95% [95% CI: 92.2% to 96.8%] after 5 years).[92]

Articles examining full-arch reconstructions reported the longest mean follow-up time (7.46 years) of all reconstruction types. Only one study was included in the present review regarding cemented full-arch reconstructions; therefore, survival rates were not statistically compared to the screw-retained group.

Failures rates for cement- and screw-retained reconstructions in the present study were analyzed not only by reconstruction type (I-SC, I-FDP, and full arch), but also by the materials used (abutment material, prosthetic material, and cement type). The failure rates for cemented reconstructions were influenced by the prosthetic material, with statistically higher rates with ceramic materials.

In the systematic review by Jung et al,[11] the survival rate of PFM single crowns was 95.4% (95% CI: 93.6%

to 96.7%) which was statistically significantly higher compared to the survival rate of all ceramic crowns of 91.2% (95% CI: 86.8% to 94.2%). When the data pool was updated in a follow-up systematic review the failure rates were very similar for PFM crowns (0.85 [95% CI: 0.51 to 1.41]) and ceramic crowns (0.86 [95%CI: 0.38 to 1.95]).[93] This clearly reflects the improvement of the biomechanical characteristics of the newer ceramic materials. In the present review, survival rates of screw-retained crowns were also not influenced by prosthetic material.

Failure rates with cemented reconstructions were not influenced by the abutment material (titanium, gold, ceramic). The screw-retained reconstructions had higher failure rates in combinations with gold abutments ($P = .062$). However, the use of ceramic abutments did not increase the risk for failure which confirms the results obtained by Sailer et al[94] who reported the 5-year survival of ceramic abutments to be 99.01% (95% CI: 93.8% to 99.9%) and 97.4% (95% CI: 96% to 98.3%) for metal abutments and that the annual failure rates with all ceramic crowns on ceramic abutments were similar to the rates observed with PFM crowns on metal abutments.

The failure rate of cemented reconstructions was not influenced by the choice of a particular cement whereas the event loss of retention depended on the type of cement. This leaves the clinician to select a cement based on the amount of preferred retention.

Technical and Biologic Complications

The results of the current review indicate a statistically significant ($P = .03$) higher overall rate of technical complications with cement-retained reconstructions compared to screw-retained reconstructions (Table 11). The recent review by Sailer et al[15] did not assess the overall rate of technical complications, but reported that the estimated cumulative incidence of technical complications at 5 and 10 years was higher with only screw-retained I-SC reconstructions and not I-FDP or full-arch I-FDP. The current review did not evaluate technical complications in terms of individual reconstruction type.

The technical complication fracture/chipping of ceramic was statistically significantly more frequent in screw-retained reconstructions compared to cemented ones (Table 11). Loosening of abutment complications were more frequent with cemented reconstructions. The total rate of technical complications, however, was statistically significantly higher with cemented reconstructions (Table 11).

Chipping of the ceramic veneer may be more likely in the presence of an access opening for an occlusal/abutment screw. In this situation, the integrity of the framework and the veneer layers are interrupted, and tension might be produced while tightening the assembly and manipulations with the screwdriver, provoking stress peaks laterally in the region of the access opening.

Although chipping of the resin veneer could not be compared between retention type, this complication was extremely frequent in screw-retained reconstructions with an event rate of 4.40 (95% CI: 1.50 to 12.88), thus making it the second most common complication for screw-retained reconstructions. These complications were also mainly seen in full-arch reconstructions and this should therefore be taken into account when designing an implant-supported reconstruction for edentulous patients.

The biologic complications and the total event rate for biologic complications were significantly increased with cement- compared to screw-retained reconstructions (Table 13). Presence of fistula/suppuration appeared statistically significantly more often with cemented reconstructions.

In the chain of processes leading to biologic complications, many host factors and biologic interactions with the inserted materials play a role. The type of retention (screw/cement) seemed to have a decisive role in the risk of developing a biologic complication (Table 13).

This is in agreement with other reports that discuss the role of cement in the development of infections and progressive bone loss[87] as well the observed improvement after removal of excess cement.[84] For bacterial colonization, even a micro-gap and a small space between the implant shoulder/abutment and supra-structure may create an anaerobic niche for undisturbed growth of a biofilm,[95–97] independent of retention type.

Data Extraction, Limitation, and Future Prognosis

Stringent inclusion and exclusion criteria were selected including a minimum mean follow-up time of 3 years for the included studies. This follow-up time is greater than that of previous studies and allows for a more accurate estimation of 5-year survival rates. 8.3% of the included studies were RCT, which is a reassuringly high number compared to that usually reported in dental literature reviews. However, the main limitation of this review is the heterogeneity between the included studies, mainly their definitions of success, survival, failure, and complications, as well as the presentation of the data and design. However with a greater number of included studies compared to previous reviews, it is hoped that the negative effect of heterogeneity can be minimized. Further, If a study did not note the absence of events, it was excluded for a statistical comparison, since it was unclear if events were present.

Another limitation to this study is the lack of a standardized definition of prosthetic failure. While implant failures were well-reported, it was not always possible

to distinguish true prosthetic failures from those where the implant failed and resulted in the reporting of a prosthetic failure. As a result, there may be an overestimation of prosthetic failure in these results. Although it is not possible to determine to exactly what degree this overestimation occurs in the various groups, it must be remembered that survival of the restoration and implant together is what is important to the patient.

For the two categories of screw-retention (one-piece and two-piece screw-retained reconstructions), the estimated event rates were calculated and compared to cement-retained reconstructions; however, due to a limitation of studies, further analyses were not performed.

In addition, a further biomechanical aspect that was not separately analyzed was the effect of an external or internal connection. This has previously been shown to have an impact on screw loosening, but little else.[98]

With respect to future prognosis of a reconstruction, the determination of which retention system leads to more failures/complications has to be complemented with the question: Which retention system is more advantageous in the successful management of future failures and complications? Handling of these complications and the cost of doing so represent further questions of importance and are recommended as avenues for future research.

CONCLUSIONS

The estimated 5-year survival rate of screw-retained reconstructions (based on a random-effects Poisson regression analysis) is similar to that for cemented reconstructions. Estimated failure rates calculated for cemented and screw-retained reconstructions were not statistically significant ($P = .63$).

There were no statistically significant differences between the failure rates of the different reconstruction types (I-SC, I-FDPs, full-arch I-FDPs).

Failures of cemented reconstructions were not statistically significantly influenced by the abutment material (titanium, gold, ceramic) or the choice of a specific cement.

The total event rate of technical complications was statistically significantly higher with cemented reconstructions. The technical complication fracture/chipping of ceramic was significantly more frequent in screw-retained reconstructions compared to the cemented ones. The loosening of abutment complication was more frequent with cemented reconstructions. The remaining technical complications such as fracture of abutment, fracture of framework, fracture of implant and screw fracture did not demonstrate statistical significance.

The total event rate for biologic complications was significantly higher with cemented compared to screw-retained reconstructions. Presence of fistula/suppuration appeared statistically significantly more often with cemented reconstructions. Outcomes of the other event rates of biologic complications such as bone loss (> 2 mm), peri-implantitis, presence of fistula/ suppuration, peri-implant mucositis, recession, and loss of implant were not statistically significantly different between the two retention systems.

Considering the risks with cemented reconstructions and the limited options for interventions after definitive cementation, it seems to be appropriate to recommend a preference towards screw retention of implant-supported reconstructions.

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