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SYSTEMATIC REVIEW

Techniques for locating the screw access hole in cement-retained implant-supported prostheses: A systematic review

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ABSTRACT

Statement of problem. Different techniques for retrieving cement-retained implant-supported prostheses have been described to minimize damage to the prostheses. Nevertheless, a classification of the described techniques remains ambiguous.

Purpose. The purpose of this systematic review was to review and classify the described techniques for recording and locating the screw access hole in cement-retained implant-supported prostheses.

Material and methods. A bibliographic search was completed on MEDLINE/PubMed, Web of Science, Scopus, and Cochrane databases. A manual search was also conducted. The articles that described or evaluated techniques for recording and locating the screw access hole of cement-retained implant-supported prostheses were included. Two investigators independently assessed the quality assessment of the studies using the Revised Cochrane risk of bias tool for randomized trials. A third examiner was consulted to resolve the lack of consensus.

Results. A total of 30 articles were included. The different methods were classified according to whether the screw access hole location was registered before or after cementation. The precementation techniques were classified into 4 subgroups: identification marks, photographic records, digital files, and precementation screw access hole location guides. The postcementation techniques were subdivided into 2 subgroups: radiographic records and postcementation screw access hole location guides.

Conclusions. Different techniques have been proposed to facilitate the location of the screw access hole in cement-retained implant-supported restorations. Although the evidence is scarce, studies seem to ascertain that some techniques, such as the use of drilling guides, orientation with cone beam computed tomography images, or holes made in the metal framework, can increase the retrievability of cement-retained implant-supported prostheses and decrease complications in the location of the screw access hole. The proposed classification summarizes precementation and postcementation techniques and provides a tool to decide the most suitable for each specific clinical situation. (J Prosthet Dent 2021;■:■-■)

Implant-supported prostheses have been reported to provide optimal treatment for missing teeth.[1,2] Similar success and survival rates have been reported for cement- and screw-retained implant-supported prostheses; however, variations in biological and mechanical complications between both designs have been described.[3-9]

Cement-retained implant-supported restorations have been correlated with a higher occurrence of biological complications than screw-retained implant-supported prostheses,[3-10] while screw-retained implant-supported prostheses provide higher retrievability.[11-13] This retrievability helps address mechanical complications such as abutment screw loosening, ceramic chipping, or screw fracture.[3-14]

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Clinical Implications

Knowing the different retrievability techniques for registering and locating screw access holes in cement-retained implant-supported prostheses may help in selecting the most appropriate technique based on the clinical situation and the available clinical resources.

Different techniques, both before and after cementation, have been reported for recording and locating the screw access hole (SAH) in cement-retained implant-supported prostheses.[15] However, the authors are unaware of a classification of the described techniques and of their efficiency. The objectives of the present systematic review were to review and classify the techniques for recording and locating the SAH in cement-retained implant-supported prostheses.

MATERIAL AND METHODS

The problem or population, intervention, comparison, outcome, study type (PICOS) question that defined the search was expressed as cemented implant-supported fixed dental prostheses; the population was defined as techniques, methods, and devices used to record and locate the SAH in cement-retained implant-supported prostheses; the comparison was not applicable; the outcome as the efficacy of the techniques to record and locate the SAH in cement-retained implant-supported prostheses; and study type comprised dental techniques and in vitro and clinical studies. Five different databases were searched without time limitation: MEDLINE/PubMed, EMBASE, World of Science, Cochrane, and Scopus (Table 1). A manual search was also conducted. Data search included articles published between 1995 and January 2021.

Table 1. Boolean search strategy

Data Base	Boolean Search
MEDLINE (PubMed)	("Dental Prosthesis, Implant-Supported"[MeSH] OR "cement retained restorations" OR "cemented implant-supported crowns" OR "cement-retained restorations" OR "cement-retained implant prosthesis") AND ("technique" OR "guide" OR "device" OR "splint" OR "index" OR "procedure" OR "method") AND ("retrieval" OR "removal" OR "reversibility" OR "retrievability" OR "screw access hole" OR "abutment screw" OR "abutment-screw")
Embase Scopus Web of Science	("Dental Prosthesis, Implant-Supported" OR "cement retained restorations" OR "cemented implant-supported crowns" OR "cement-retained restorations" OR "cement-retained implant prosthesis") AND ("technique" OR "guide" OR "device" OR "splint" OR "index" OR "procedure" OR "method") AND ("retrieval" OR "removal" OR "reversibility" OR "retrievability" OR "screw access hole" OR "abutment screw" OR "abutment-screw") NOT [medline]/lim AND [embase].

All titles and abstracts were first assessed to select technique description articles that described or evaluated techniques to record and locate the SAH in cement-retained implant-supported prostheses. This systematic review conformed to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[16]

After evaluating the full text of the manuscripts according to the defined inclusive criteria, articles assessing different topics and articles evaluating different types of cement of implant-supported prostheses or other retrieval techniques such as transverse fixations or holes in the framework for rotating lever systems were considered ineligible.

Two calibrated reviewers (N.M.O., M.G-.P.) collected the data from the selected articles into structured tables. Discrepancies were resolved by consensus, and a third examiner (M.R-.L.) was consulted. Differences between the reviewers were assessed with the Cohen kappa statistic.[17]

The authors are unaware of a specifically designed tool to assess the risk of bias for in vitro studies or dental technique manuscripts; therefore, a risk of bias assessment focused on randomized trials studies (Revised Cochrane risk of bias tool for randomized trials, RoB 2) was selected (Table 2).[18]

RESULTS

The database searches resulted in 496 articles. After eliminating duplicates and reading the title and the abstract, 43 were included for full-text evaluation. After reading the full text, 13 publications were discarded. A total of 30 articles were included for this review (Fig. 1).

The different techniques for recording and locating the SAH in cement-retained implant-supported prostheses were classified as precementation[19-37] or postcementation procedures.[38-45] The precementation techniques were divided into 4 subgroups: identification marks on the prosthesis,[19,33,35] photographic records,[21,22,25,28,29,34,37] digital records,[26] and precementation SAH location guides[20,23,24,27,30,32,36] (Table 3). The postcementation techniques were divided into 2 subgroups: radiographic records[39-41] and postcementation SAH location guides[38,42-45] (Table 4).

A total of 18 reviewed studies described precementation techniques to record the SAH,[19-37] and 8 articles reported postcementation methods to locate the SAH.[38-45] Furthermore, 4 studies aimed to assess the efficacy of previously described retrieval techniques, including 1 in vitro study that evaluated the accuracy of a precementation guide technique,[46] 1 clinical study that evaluated the efficacy of a technique of an identification mark technique to locate SAH after cementation,[33] and 2 articles that evaluated the accuracy of a technique using cone beam computer tomography (CBCT).[47,48]

A classification aiming to summarize the reviewed techniques, provide a guide for consulting their

Table 2. Revised Cochrane risk of bias tool

Domain	Item
1. Risk of bias arising from the randomization process	1.1 Was the allocation sequence random?
	1.2 Was the allocation sequence concealed until participants were enrolled and assigned to interventions?
	1.3 Did baseline differences between intervention groups suggest a problem with the randomization process?
2.a. Risk of bias due to deviations from the intended interventions (effect of assignment to intervention)	2.1. Were participants aware of their assigned intervention during the trial?
	2.2. Were carers and people delivering the interventions aware of participants' assigned intervention during the trial?
	2.3. If Y/PY/NI to 2.1 or 2.2: Were there deviations from the intended intervention that arose because of the trial context?
	2.4 If Y/PY to 2.3: Were these deviations likely to have affected the outcome?
	2.5. If Y/PY/NI to 2.4: Were these deviations from intended intervention balanced between groups?
	2.6 Was an appropriate analysis used to estimate the effect of assignment to intervention?
	2.7 If N/PN/NI to 2.6: Was there potential for a substantial impact (on the result) of the failure to analyze participants in the group to which they were randomized?
2. Risk of bias due to deviations from the intended interventions (effect of adhering to intervention)	2.1. Were participants aware of their assigned intervention during the trial?
	2.2. Were carers and people delivering the interventions aware of participants' assigned intervention during the trial?
	2.3. [If applicable:] If Y/PY/NI to 2.1 or 2.2: Were important non-protocol interventions balanced across intervention groups?
	2.4. [If applicable:] Were there failures in implementing the intervention that could have affected the outcome?
	2.5. [If applicable:] Was there non-adherence to the assigned intervention regimen that could have affected participants' outcomes?
	2.6. If N/PN/NI to 2.3, or Y/PY/NI to 2.4 or 2.5: Was an appropriate analysis used to estimate the effect of adhering to the intervention?
3. Missing outcome data	3.1 Were data for this outcome available for all, or nearly all, participants randomized?
	3.2 If N/PN/NI to 3.1: Is there evidence that the result was not biased by missing outcome data?
	3.3 If N/PN to 3.2: Could missingness in the outcome depend on its true value?
	3.4 If Y/PY/NI to 3.3: Is it likely that missingness in the outcome depended on its true value?
4. Risk of bias in measurement of the outcome	4.1 Was the method of measuring the outcome inappropriate?
	4.2 Could measurement or ascertainment of the outcome have differed between intervention groups?
	4.3 If N/PN/NI to 4.1 and 4.2: Were outcome assessors aware of the intervention received by study participants?
	4.4 If Y/PY/NI to 4.3: Could assessment of the outcome have been influenced by knowledge of intervention received?
	4.5 If Y/PY/NI to 4.4: Is it likely that assessment of the outcome was influenced by knowledge of intervention received?
5. Risk of bias in selection of the reported result	5.1 Were the data that produced this result analyzed in accordance with a pre-specified analysis plan that was finalized before unblinded outcome data were available for analysis?
	Is the numerical result being assessed likely to have been selected, on the basis of the results, from…
	5.2. … multiple eligible outcome measurements (eg, scales, definitions, time points) within the outcome domain?
	5.3 … multiple eligible analyses of the data?

N, no; NI, no information; PN, probably no; PY, probably yes; Y, yes.

classification, and assist clinicians in selecting the most appropriate technique according to the clinical situation is presented in Tables 5 and 6.

Cohen kappa values between examiners were 0.942 (P<.001), indicating a very high agreement between the examiners. For the risk of bias of the selected studies, the technique description articles were considered as not valuable, as all the fields were classified as nonapplicable. For the rest of the manuscripts, a high risk was considered when 1 of the items was classified as nonapplicable or high risk or when more than 3 items were rated as medium risk. A medium risk was assigned to studies without any high-risk items, but with 1 to 4 items classified as medium risk. When there were no nonapplicable items or less than 1 item was classified as medium risk, the study was classified as low risk. Because most of the included manuscripts were dental technique or clinical report articles, they were classified as not valuable.[18] The remaining 4 manuscripts were considered as high risk (Table 7).

DISCUSSION

Different methodologies have been described to assist in retrieving cement-retained implant-supported prostheses. Some of the techniques included modifications in the design of the prostheses such as using additional screw systems,[13] guide holes for introducing special removing tools,[49-51] and lingual slot designs in the framework.[52] Other techniques focused on facilitating the removal procedure by using interim cements[53] or using an erbium-doped yttrium aluminum garnet (erbium YAG) laser for removing the cement.[54,55] However, these methods may fail. Therefore, precementation and postcementation techniques to register and locate the SAH might assist in retrievability.

In the present systematic review, a classification of the registration and location of the SAH of the abutments of cement-retained implant-supported prostheses is proposed. The techniques were divided according to whether records were made to locate the SAH before or after cementation procedures to facilitate clinical choice.

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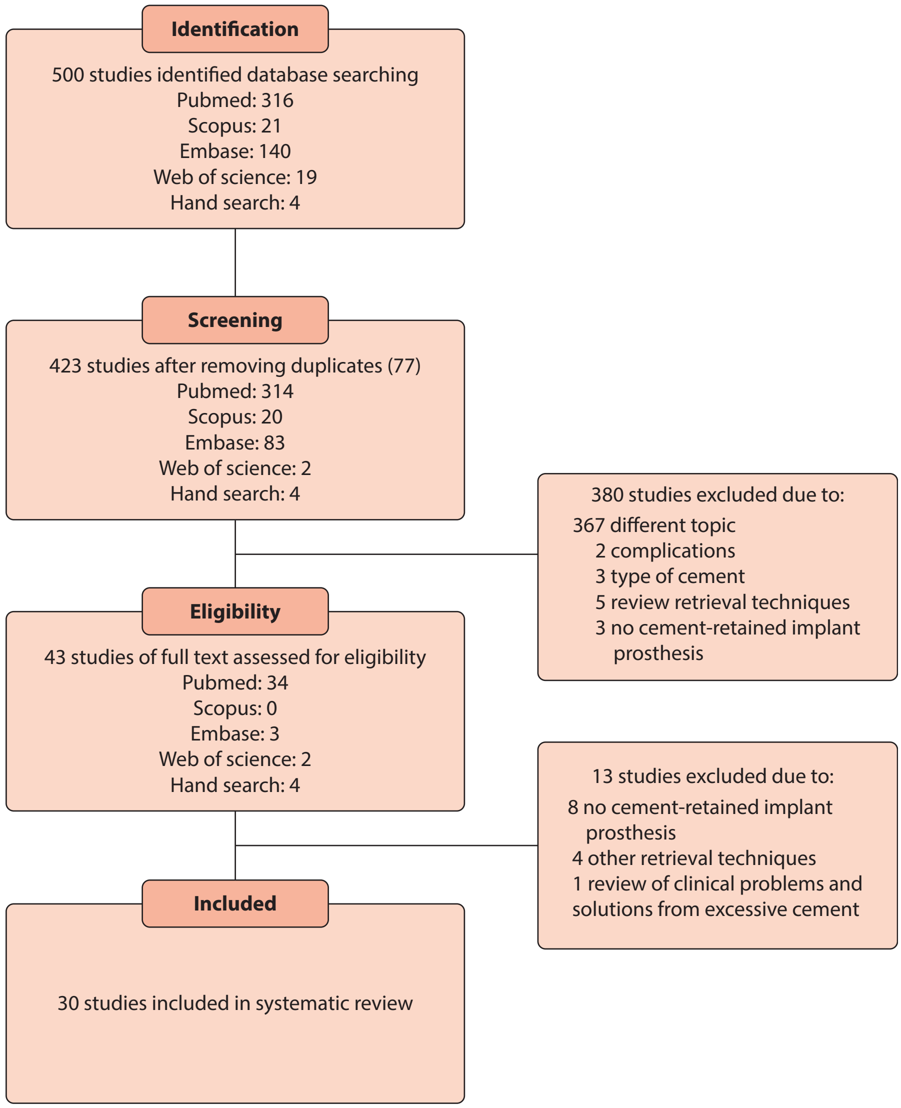

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagram of study selection.

Among the precementation techniques, identification marks in the design of the prosthesis are a straightforward option and can be prepared by the dental laboratory technician without significant cost. However, they would be unacceptable in visible areas and thus contraindicated for a facially located SAH in anterior prostheses.[19,35]

Among the precementation techniques reviewed, the photographic record methods[21,22,25,28,29,34,37] present the main advantage of not requiring physical storage space. They are straightforward to perform, requiring little time or additional cost. Except for the Lee technique,[29] the main disadvantage of the photographic record precementation techniques is that these methods do not provide information on implant abutment angulation. Furthermore, some of those precementation photographic techniques may require expertise with a photographic editing program.[22,28,29,37]

With the introduction of computer-aided design and computer-aided manufacturing (CAD-CAM) technologies, selecting precementation techniques that use digital files[26] and 3-dimensional (3D) images of the SAH registry provides straightforward digital availability, no additional cost, and no physical storage. However, the precementation methods with digital files require an intraoral or laboratory scanner.

The precementation techniques that use guides to locate the SAH[20,23,24,27,30,32,36,38,42-45] typically require a more labor-intensive procedure, since the guide has to be fabricated. Typically, fabricating SAH location guides increases laboratory time and cost.

In conventionally manufactured precemented SAH location guides,[20,23,24,27,30,31] physical storage space is required, and, upon subsequent modifications to the restoration or adjacent teeth, the guide may not seat completely, decreasing accuracy. Within this group,

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Table 3. Precementation techniques reviewed for recording screw access hole in cement-retained implant-supported prostheses classified into 4 groups: identification marks on prosthesis, photographic records, digital records, and screw access hole location guides

Reference	Technique	Article Type	Description
Schwedhelm and Raigrodski,[19] 2006	Identification marks on the prosthesis	Dental technique	Small and well-defined porcelain stain placed on occlusal surface of implant-supported metal-ceramic restoration before final glazing procedure. Stain located at SAH.
Nissan et al,[33] 2016		NRSI	In metal-ceramic implant-supported FDPs, Ø0.6-mm hole made in metal framework to facilitate localization of SAH. In definitive restoration, hole covered by veneering porcelain.
Schoenbaum et al,[35] 2017		Clinical report	Slight depression made with fine diamond rotary instrument at exit location of SAH, followed by application of white or brown opaquer porcelain in this area.
Daher and Morgano,[21] 2008	Photographic records	Dental technique	Intraoral photographs (facial and incisal view) made of implant abutment placed on implant and with restoration seated on implant abutment, with use of periodontal probe placed vertically and horizontally, as guide for location of SAH.
Figueras-Alvarez et al,[22] 2010		Dental technique	Two photographs of definitive implant cast used: one with implant restoration seated on implant abutment (restoration photograph) and another without implant restoration, just with implant abutment (abutment photograph). Images superimposed by using photographic editing software program. Location of SAH shown by increasing translucency on restoration photograph.
Patil and Patil,[25] 2013		Dental technique	One occlusal photograph of implant restoration placed on definitive implant cast indicating access points measured with thickness gauge and marked with marker.
Figueras-Alvarez and Cano-Batalla,[28] 2014		Dental technique	Two photographs of definitive implant cast used: one with implant restoration seated on implant abutment (restoration photograph) and another without implant restoration, just with implant abutment (abutment photograph). Images superimposed by using presentation editing software program. Location of SAH shown by increasing translucency on restoration photograph.
Lee,[29] 2015		Dental technique	Two photographs of definitive implant cast used: one with implant restoration seated on implant abutment (restoration photograph) and another without implant restoration, just with implant abutment (abutment photograph). Images superimposed by using presentation editing software program. Location of SAH shown by increasing translucency on restoration photograph.
Oh and Moon,[34] 2016		Dental technique	Two neodymium magnets used. In definitive cast, with implant abutment screwed to implant analog, one magnet positioned into SAH. Then, restoration seated on abutment and another magnet automatically positioned on top through magnetic attraction, representing location of SAH. Occlusal photograph made to record this location.
Michalakis and Hirayama,[37] 2018		Dental technique	Two photographs of definitive implant cast used: one with implant restoration seated on implant abutment (restoration photograph) and another without implant restoration, just with implant abutment (abutment photograph). Images superimposed using presentation editing software program. Location of SAH shown by increasing translucency on restoration photograph.
Park and Yoon,[26] 2013	Digital files	Dental technique	Two digital scans obtained by digitizing definitive cast: one with restoration seated on abutment and another just with abutment, attached with long screw. Scan files superimposed using a CAD software program to locate and register SAH.
Hill,[20] 2007	SAH location guides: Conventional method	Dental technique	On occlusal surface of definitive restoration, 2-mm bead of baseplate wax used to mark location of SAH. Then, silicone index adapted to occlusal surfaces of teeth made and stored. Later used as drilling guide to locate SAH.
Lautensack et al,[24] 2012		Dental technique	Vacuum-formed guide made with 2-mm-thick material on implant cast with restoration seated on abutment. Guide positioned on cast without implant restoration, just with implant abutment. Afterward, guide marked and drilled in SAH area, followed by placement of guiding sleeve (titanium tubes) using autopolymerizing acrylic resin material.
Tarlow,[23] 2012		Dental technique	Vacuum-formed guide made with 0.5-mm material on implant cast with restoration seated on abutment. Guide positioned on cast without implant restoration, just with implant abutment. Afterward, guide marked and drilled in SAH area.
Wadhwani and Chung,[27] 2013		Dental technique	Rectangular flat plate light-polymerizing material with hole in center placed on implant cast with abutment. Long screwdriver used to cross plate and engage abutment screw. Then, silicone material adapted plate to occlusal surfaces of adjacent teeth.
Kheur et al,[31] 2015		Clinical report	Vacuum-formed guide with 2-mm-thick material on implant cast with restoration seated on abutments. Guide placed on implant cast, without restoration. Then, guide marked, drilled, and plastic guide tubes positioned in SAH area.
Kang and Lee,[30] 2015		Dental technique	Handpiece sleeve (outer sleeve) and guide sleeve (inner sleeve) designed using CAD software program. Vacuum-formed guide fabricated on implant

(*continued on next page*)

Table 3. (*Continued*) Precementation techniques reviewed for recording screw access hole in cement-retained implant-supported prostheses classified into 4 groups: identification marks on prosthesis, photographic records, digital records, and screw access hole location guides

Reference	Technique	Article Type	Description
			cast with restoration. Guide positioned on implant cast without restoration, marked and drilled in SAH area. Guide sleeve placed through hole, with projected cylinder of guide sleeve in screw channel of abutment, fixed with autopolymerizing acrylic resin.
Lee,[32] 2015	SAH location guides: CAD/CAM method	Dental technique	SAH location guide designed by superposition of digital scan files of implant abutment and restoration. Guide manufactured by milling or additive techniques.
Mai et al,[36] 2017		Dental technique	SAH location guide designed by superposition of digital scan files of implant abutment and restoration. Scan file of implant abutment made with metal column inserted into canal of implant abutment. Both intraoral digital scans superimposed and used to design of SAH location guide.

CAD, computer-aided design; CAM, computer-aided manufacturing; FDP, fixed dental prosthesis; NRSI, nonrandomized study of intervention; SAH, screw access hole.

Table 4. Postcementation techniques for locating the screw access hole in cement-retained implant-supported prostheses classified into 2 groups namely radiographic records and SAH location guides

Reference	Technique	Article Type	Description
Patil,[39] 2011	Radiographic records	Dental technique	Straight line parallel to longitudinal axis of implant, through center, and extended to occlusal surface drawn on digital periapical radiograph.
Wicks et al,[40] 2012		Dental technique	Linear tracing of axis of implant performed in sagittal and frontal views to determine 3D location of SAH in CBCT. Traces intersect by using cross reference points and visualized from coronal view. Intersection on occlusal face of drawn lines indicates SAH location.
Buzayan et al,[41] 2014		Clinical report	Periapical radiographic image obtained with digital camera. Photograph enlarged in software program until width of implant platform equal to actual diameter. Prefabricated cylinder shape inserted, and radiographic image superimposed, adjusting to actual diameter of screw channel. Mesial and distal distances from end of cylinder to adjacent teeth measured to determine SAH on occlusal surface.
Doerr,[38] 2002	SAH location guides: Conventional	Dental technique	Vacuum splint made on cast obtained from intraoral impression with cemented restoration. Splint adapted to definitive implant cast and long screws as reference to mark and drill it in SAH area.
Radi and Alfahd,[42] 2016		Dental technique	Custom drilling guide manufactured on definitive implant cast with impression coping screwed to analogs. Guide made with autopolymerizing acrylic resin covering occlusal surfaces of adjacent teeth. Splint drilled in holes left by impression copings to locate SAH.
Ahmed et al,[43] 2016		Dental technique	Two casts employed: definitive implant cast and a postcementation cast. Autopolymerizing PMMA guide made on postcementation cast placed on definitive cast and drilled following implant axis orientation.
Mai et al,[44] 2016	Postcement location guides: CAD/CAM	Clinical report	Acrylic resin CAD-CAM milled drilling guide made from superimposition of CBCT and intraoral digital scan.
Asiri et al,[45] 2018		Dental technique	Cast from postcementation conventional impression digitized with desktop scanner. File aligned to postcementation CBCT scan in surgical planning software program, placing virtual implant in same position as clinical one. 3D-printed acrylic resin CAD-CAM drilling guide manufactured.

CAD, computer-aided design; CAM, computer-aided manufacturing; CBCT, cone beam computed tomography; PMMA, polymethyl methacrylate; SAH, screw access hole.

vacuum-formed SAH location devices[22,23,31] aim to guide drilling the SAH. Some of them provide the added advantage of identifying the 3D location,[24,31] especially useful where angulated implant abutments have been used, making locating the screw especially challenging. SAH location guides can be manufactured chairside without laboratory costs,[20,27] even providing a 3D location of the SAH.[27]

The precementation SAH location guides manufactured using CAD-CAM techniques[32,36] enable digital storage of the records and provide a 3D record of the SAH location. However, an intraoral or laboratory scanner is required.[44,45] Once the implant-supported prosthesis has been cemented and if additional precementation records are lacking, these techniques can be a useful resource to locate the SAH and facilitate retrieval of the prosthesis.

Postcementation radiographic records techniques use periapical radiographs allowing the approximation of the SAH location with respect to the implant position in an economical and straightforward approach.[39,41] However, postcementation radiographic records methods provide only information on the mesiodistal angulation, so the clinical procedure to locate the SAH is less predictable. One study reported a postcementation technique to find SAHs using CBCT images, providing the 3D position of the implant with respect to the implant crown.[40] However, all the postcementation radiographic records techniques have the drawback of subjecting the patient to additional radiation exposure and, in some situations, the radiographic records might be compromised by scattering from metal restorations, abutments, and implants. These techniques are indicated when precementation techniques have not been used or useful precementation

Table 5. Comparative analysis of precementation techniques reviewed for locating screw access hole in cement-retained implant-supported prostheses

Reference	Cost	Expected Time	Need of Extra Material/Equipment	In-Office/ Dental Laboratory	Difficulty of Development	Need to Store	Register of SAH	Useful for Multiple FDPs	Validity with Posterior changes*	Accuracy Evaluated in Studies
Schwedhelm and Raigrodski,[19] 2006	Low	Low	No	Dental laboratory	Low	No	2D	Yes	Yes	No
Nissan et al,[33] 2016	Low	Low	No	Dental laboratory	Low	No	2D	Yes	Yes	1 in vivo study:[32] 274 IFDPs (test group)/119 IFDPs (control group) Refabrication of ISPs (1.45% test group vs 6.72% control group). (P=.012).
Schoenbaum et al,[35] 2017	Low	Low	No	Dental laboratory	Low	No	2D	Yes	Yes	No
Daher and Morgano,[21] 2008	Low	Low	Photographic camera	In-office	Low	No	2D	No	Yes	No
Figueras-Alvarez et al,[22] 2010	Low	Medium	Photographic camera and software	In-office	Low	No	2D	Yes	Yes	No
Patil and Patil,[25] 2013	Low	Low	Photographic camera	In-office	Low	No	2D	Yes	Yes	No
Figueras-Alvarez and Cano-Batalla,[28] 2014	Low	Medium	Photographic camera and software	In-office	Low	No	2D	Yes	Yes	No
Lee,[32] 2015	Low	Medium	Photographic camera wooden wedge and software	In-office	Low	No	2D	No	Yes	No
Oh and Moon,[34] 2016	Low	Low	Photographic camera and magnets	In-office	Low	No	2D	Yes	Yes	No
Michalakis and Hirayama,[37] 2018	Low	Medium	Photographic camera and software	In-office	Low	No	2D	Yes	Yes	No
Park and Yoon,[26] 2013	Low	Medium	Intraoral scanner	In-office	Medium	No	3D	Yes	Yes	No
Hill,[20] 2007	Low	Low	No	In-office	Low	Guide	2D	Yes	Difficult settlement of guide	No
Lautensack et al,[24] 2012	High	High	Vacuum machine and titanium guide tubes	Dental laboratory/ In-office	High	Guide	3D	Yes	Difficult settlement of guide	No
Tarlow,[23] 2012	Medium	Medium	Vacuum machine	Dental laboratory/ In-office	Medium	Guide	2D	Yes	Difficult settlement of guide	No
Wadhwani and Chung,[27] 2013	Low	Medium	No	In-Office	Medium	Guide	3D	No	Difficult settlement of guide	No
Kheur et al,[31] 2015	High	High	Vacuum machine and plastic guide tubes	Dental laboratory/ In-office	High	Guide	3D	Yes	Difficult settlement of guide	No
Lee,[32] 2015	High	High	CAD-CAM software/ machine	Dental laboratory	Medium	No	3D	Yes	Difficult settlement of guide	1 in vitro study[46]: SCs. 0, 15 and 30 degrees. For 30-degree angulation, smaller screw access holes vs control (freehand drilling group) (P<.001); No statistical differences found between groups for 0- or 15-degree angulation. Smaller standard lateral deviations than control group.
Kang and Lee,[30] 2015	High	High	Vacuum machine and CAD-CAM software/ machine	Dental laboratory	High	Guide	3D	No	Difficult settlement of guide	No
Mai et al,[36] 2017	High	High	Intraoral scanner and CAD-CAM software/ machine	Dental laboratory	High	No	3D	Yes	Difficult settlement of guide	No

CAD, computer-aided design; CAM, computer-aided manufacturing; CBCT, cone beam computed tomography; IFDP, implant fixed dental prosthesis; SAH, screw access hole; SC, single crown.
*In prosthesis or adjacent teeth.

records are not available, making freehand drilling the only option to locate the SAH.

Conventionally fabricated postcementation SAH location guides,[38,42,43] unlike radiographic techniques, present

Table 6. Comparative analysis of postcementation techniques reviewed for locating screw access hole in cement-retained implant-supported prostheses

Reference	Cost	Expected Time	Need of Extra Material/ Equipment	In-Office/ Dental Laboratory	Ease of Development	Need to Store	Register of SAH	Useful for Multiple FDPs	Validity with Posterior Changes*	Accuracy Evaluated in Studies
Patil,[39] 2011	Low	Low	Intraoral dental x-ray machine and software	In-office	Low	No	2D	Yes	Yes	No
Buzayan et al,[41] 2014	Low	Medium	Intraoral dental x-ray machine, digital camera and software	In-office	Low	No	2D	Yes	Yes	No
Wicks et al,[40] 2012	Medium	Medium	CBCT and software	In-office	Low	No	3D	Yes	Yes	2 in vitro studies[46,47]: - No control group. - Metal-ceramic (MC) SCs: 80% success in location; 83% in direction (angulated impl.); 100% success in direction in straight implants.[46] -Ceramic (C) vs MC. SCs. Success rate 96.9% in location and 93.8% in direction (MC) vs 78.1% in location and 59.4% in direction (C).[47]
Doerr,[38] 2002	Medium	High	Vacuum machine	Dental laboratory/In-office	Medium	Yes	2D	Yes	Yes	No
Radi and Alfahd,[42] 2016	Medium	Medium	No	In-office	Medium	Yes	3D	Yes	Difficult settlement of guide	No
Ahmed et al,[43] 2016	Medium	High	No	Dental laboratory/In-office	High	Yes	2D	Yes	Yes	No
Mai et al,[44] 2016	High	High	CBCT, intraoral scanner and CAD-CAM software/ machine	Dental Laboratory	High	No	3D	Yes	Yes	No
Asiri et al,[45] 2018	High	High	CBCT, extraoral scanner and CAD-CAM software/ machine	Dental Laboratory	High	No	3D	Yes	Yes	No

IFDP, implant fixed dental prosthesis; SAH, Screw access hole; SC, single crown. *In prosthesis or adjacent teeth.

the drawback of requiring the definitive cast. Moreover, a clinical impression of the prosthesis must be made, with additional time and cost.[38,43] However, these techniques might deliver a more accurate SAH location than radiographic techniques and more precise seating than precementation SAH location guides, as they are not affected by changes in the prosthesis or adjacent teeth.

Postcementation SAH location guides fabricated by using CAD-CAM technology can obtain an accurate location of the SAH with both subtractive and additive manufacturing methods.[44,45] However, these techniques require the availability of digital technology such as CBCT, intraoral or extraoral scanner, and CAD-CAM laboratory procedures, which may restrict use. Furthermore, in the technique described by Asiri et al[45] in 2018, it is not necessary to have the definitive implant cast as in conventionally manufactured SAH location guide techniques.

Postcementation techniques[38-45] might provide less accurate information on the SAH position as to whether an angulated implant abutment was used because they all locate the SAH with the longitudinal axis of the implant as a reference. The SAH position can only be estimated if the restoration is less radiopaque than the implant abutment when using postcementation techniques that include CBCT imaging.[44,45]

The present systematic review reviewed and classified techniques to register or locate SAHs in cement-retained implant-supported prostheses. However, studies assessing the accuracy of precementation and postcementation techniques for locating the SAH are sparse.[33,46-48] The only techniques in which efficacy was evaluated were the technique followed by Park and Yoon[26] combined with Lee's[29] method and the technique followed by Nissan et al.[33]

Lee et al[46] compared the accuracy of CAD-CAM–drilled SAH location guides versus freehand drilling, reporting that CAD-CAM guides significantly improved

Table 7. Revised Cochrane risk of bias assessment

Author	Year	Study Design	RoB (Randomization Process)	RoB (Effect of Assignment to Intervention)	RoB (Effect of Adhering to Intervention)	Missing Outcome Data	RoB in Measurement of the Outcome	RoB in Selection of the Reported Result	Overall Risk of Bias
Doerr[38]	2002	Dental technique	NA	NA	NA	NA	NA	NA	High
Schwedhelm and Raigrodski[19]	2006	Dental technique	NA	NA	NA	NA	NA	NA	High
Hill[20]	2007	Dental technique	NA	NA	NA	NA	NA	NA	High
Daher and Morgano[21]	2008	Dental technique	NA	NA	NA	NA	NA	NA	High
Figueras-Alvarez et al[22]	2010	Dental technique	NA	NA	NA	NA	NA	NA	High
Patil[39]	2011	Dental technique	NA	NA	NA	NA	NA	NA	High
Wicks et al[40]	2012	Clinical report	NA	NA	NA	NA	NA	NA	High
Lautensack et al[24]	2012	Dental technique	NA	NA	NA	NA	NA	NA	High
Tarlow[23]	2012	Dental technique	NA	NA	NA	NA	NA	NA	High
Patil and Patil[25]	2013	Dental technique	NA	NA	NA	NA	NA	NA	High
Park and Yoon[26]	2013	Dental technique	NA	NA	NA	NA	NA	NA	High
Wadhwani and Chung[27]	2013	Dental technique	NA	NA	NA	NA	NA	NA	High
Figueras-Alvarez and Cano-Batalla[28]	2014	Dental technique	NA	NA	NA	NA	NA	NA	High
Buzayan et al[41]	2014	Dental technique	NA	NA	NA	NA	NA	NA	High
Lee[29]	2015	Dental technique	NA	NA	NA	NA	NA	NA	High
Kheur et al[31]	2015	Clinical report	NA	NA	NA	NA	NA	NA	High
Lee[32]	2015	Dental technique	NA	NA	NA	NA	NA	NA	High
Kang and Lee[30]	2015	Dental technique	NA	NA	NA	NA	NA	NA	High
Nissan et al[33]	2016	NRSI	Low	Low	Low	Low	Low	Low	High
Radi and Alfahd[42]	2016	Dental technique	NA	NA	NA	NA	NA	NA	High
Ahmed et al[43]	2016	Dental technique	NA	NA	NA	NA	NA	NA	High
Oh and Moon[34]	2016	Dental technique	NA	NA	NA	NA	NA	NA	High
Mai et al[44]	2016	Clinical report	NA	NA	NA	NA	NA	NA	High
Lee et al[46]	2016	In vitro	NA	Low	Low	Low	Low	Low	High
Schoenbaum et al[35]	2017	Clinical report	NA	NA	NA	NA	NA	NA	High
Mai et al[36]	2017	Dental technique	NA	NA	NA	NA	NA	NA	High
Asiri et al[45]	2018	Dental technique	NA	NA	NA	NA	NA	NA	High
Michalakis and Hirayama[37]	2018	Dental technique	NA	NA	NA	NA	NA	NA	High
Neshandar et al[47]	2018	In vitro	NA	Low	Low	Low	Low	Low	High
Neshandar et al[48]	2020	In vitro	NA	Low	Low	Low	Low	Low	High

NA, not applicable; NRSI, nonrandomized study of intervention; RoB, risk of bias.

the precision of SAH location and reduced the damage to the crown and abutment, particularly when the implants were angled.

In a retrospective clinical study, Nissan et al[33] assessed the long-term survival rates of cement-retained metal-ceramic implant-supported prostheses

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with a hole in the metal framework under the veneer porcelain. The authors reported a lower rate of refabrication when using this technique than the control group (1.45% versus 6.72% [P=.012]).

Two studies assessed the efficacy of CBCT in determining the location and direction of SAHs in cement-retained implant-supported crowns. In metal-ceramic crowns, the results showed success rates of 100% in straight implants and 80% in angled implants. When comparing the accuracy of metal-ceramic versus ceramic restorations, a higher success rate was found for metal-ceramic restorations (96.9% in location and 93.8% in direction) than in ceramic restorations (78.1% in location and 59.4% in direction, P<.01).[46-48] Therefore, the use of CBCT may be helpful, with higher success in straight than in angled abutments and better results in metal-ceramic than in ceramic restorations.

CONCLUSIONS

Based on the findings of this systematic review, the following conclusions were drawn:

1. Different techniques have been proposed to facilitate the location of the SAH in cement-retained implant-supported restorations.
2. Although the evidence is scarce, some techniques, such as the use of drilling guides, orientation with CBCT, or holes made in the metal-framework, can increase the retrievability of cement-retained implant-supported prostheses and decrease the prosthesis complications in the location of the SAH.
3. The proposed classification summarizes precementation and postcementation techniques and provides a tool to decide the most suitable for each specific clinical situation.

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