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Techniques for retrieving the fractured abutment screws in screw-or cement-retained implant-supported prostheses. A systematic review

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Abstract

Aim
In implant dentistry, broken abutment screws in implant-supported prostheses constitute a difficult problem that demands exact retrieval methods for effective management. This systematic review intends to evaluate several extraction techniques for fractured abutment screws, with a focus on technology integration, retention method implications, heat management, and efficient abutment screw fracture categorization.

Material and methods
This systematic review encompassed a comprehensive analysis of various methodologies employed for fractured abutment screw retrieval in both screw- and cement-retained implant-supported prostheses, integrating studies from 2010 to October 2023. To conduct the search, relevant keywords and controlled vocabulary were used in databases including PubMed, Scopus, Web of Science, Google Scholar, and Cochrane. With terms like "Abutment Screw", "Dental Implant Screw", "Fractured Abutment Screw," and "Abutment Screw Retrieval," the search was limited to papers published between 2010 and October 2023 to ensure thorough coverage. 18 studies were reviewed, and a total of 86 publications were initially found.

Results
The review uncovered developments in the integration of technology, consequences of retention procedures, efficient heat management tactics, specialized therapeutic treatments, preservation methods, and non-invasive retrieval techniques.

Conclusions
For fractured abutment screw retrieval to be successful in implant dentistry, innovative technology, cautious retention technique selection, and good heat management strategies, among other factors, are essential. The conclusions highlight the necessity for accuracy, flexibility, and patient-centred treatment while also highlighting the significance of continued research to improve patient outcomes.

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Keywords

Fractured abutment screw, abutment screw retrieval, management, techniques

INTRODUCTION

In implant-supported prostheses, broken abutment screws present a serious problem that affects the comfort and functionality of the patient(1,2,3). The occurrence rate of abutment screw fracture was reported to be in the range of 0.5% to 8% with a 3.9% incidence of fractured implant-abutment screws and a 6.7% incidence of loosened implant-abutments screws(4). Factors that may cause abutment screw fracture include occlusal overload, parafunctional habits such as bruxism, design of implant-abutment connection, abutment screw design, material properties, and the lack or loss of adequate preload, superstructure misalignment, non-passive framework, presence of cantilevers, overloading, or malfunction, repeated retightening of loose screw and fatigue character and yield strength of the screw material. When a prosthetic screw fragment becomes wedged in the internal threads of the implant, it becomes difficult, sometimes impossible, to retrieve(5,6). Preloading the abutment screw and occlusal loading could wedge the fractured abutment into the implant and require high pull-out force. Fluids in the mouth such as saliva, blood, and the limited visibility of the dental implant make it difficult to access(7,8,9).

Approaches for removing a fractured screw are the use of a custom-made device such as screwdriver or the use of a special kits available for the specific implant system such as Retrieval Instruments (Nobel Biocare, Kloten, Switzerland), Implant Repair Kit (ITI, Straumann AG, Basel, Switzerland) and Neo Screw remover Kit (Neobiotech co. ltd., Seoul, South Korea) for such purpose and other methods described in this review(2,10). The ease of removing the fractured screw depends on the level of the fracture. Abutment screw fractures occurs

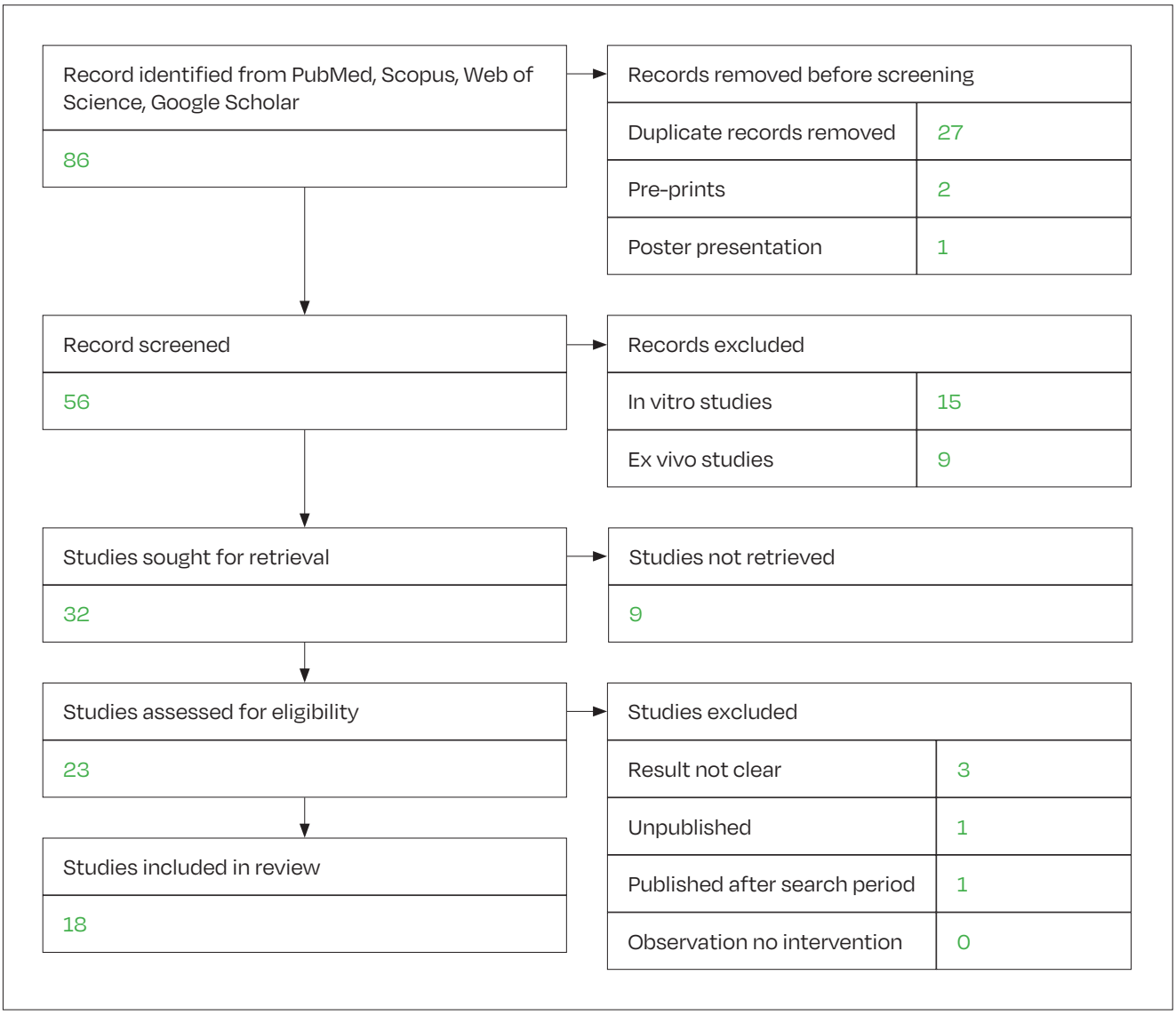

Fig. 1 PRISMA Flowchart for the review

S.No	Author and year	Type of study	Name of Implant/ Type	Accessibility tool	Method
1.	Satterthwaite J et al. (19)	Clinical report	Branemark Tiunite	a clinical microscope	Using endodontic instrument
2.	Patel RD et al. (13)	Clinical report	Astra Osseospeed	Surgical loupe and microscope	an ultrasonic instrument with an ultrafine spreader tip, was used
3.	Maalhagh-Fard A et al. (20)	Clinical report	Not specified	None	By creating a trough between the abutment screw head and the internal aspect of the implant using a high-speed handpiece with a no. 2 round rotary cutting instrument under copious irrigation. The head of the abutment screw was then loosened with the use of fine forceps.
4.	Yilmaz B et al. (21)	Technique demonstration	Unknown	None	Appropriate size fragment removal tool (Fragment Fork, 1mm and 1.4mm) in slow speed handpiece is used to engage the exposed surface of the screw fragment. Reverse torque is applied on the fragment.
5.	Walia MS et al. (22)	Clinical report	Zimmer	None	A notch was made on the occlusal surface of abutment screw between the center and periphery with a fine tapered carbide bur (Tri Hawk). Ultrasonic scaler tip was engaged the notch and moved counterclockwise.
6.	Taira Y et al. (23)	Clinical report	Branemark	None	stainless steel tubes of 2 sizes were prepared to fabricate a guide tube. The narrow tube (1.5 mm external diameter, 4mm length) was attached inside the thick tube (1.8 mm external diameter, 4mm length) with cyanoacrylate bonding agent to form a single tube 6mm long. A hole was drilled in the centre of failed abutment screw with a tungsten carbide bur No 330 (diameter of head 0.7mm and shank 1.5 mm) in a highspeed air-turbine through the guide tube
7.	Gooty JR et al. (3)	Clinical report	root form cylindrical implant with internal hex	None	A 1 mm deep pit was made across the occlusal portion of broken screw fragment with ¼ round bur in a high speed handpiece. Using ultrasonic scaler with no 3 tip placed in the pit prepared moving in anticlockwise direction slowly the broken abutment screw was retrieved
8.	Imam AY et al. (24)	Clinical report	Spline; Zimmer Denta	None	For three screws Special fork-shaped tip of long-shank stainless steel instrument (Fragment Fork) was used to thread the fractured screw fragment and re-tapping tool used to retap the damaged threads by gently rotating the re-tapping tool clockwise not more than 180 degrees and then counterclockwise rotation. For one screw ultrasonic instrument was used

Tab. 1A Characteristics of studies included in the systematic review

S.No	Author and year	Type of study	Name of Implant/ Type	Accessibility tool	Method
9.	Campolat C et al. (25)	Clinical report	Not specified	None	Fractured screw was not retrievable and inner walls of the implant damaged. The implant interior and remaining screw were machined. A cast dowel with ball attachment was fabricated using chrome cobalt alloy and cemented with glass ionomer cement
10.	Flanagan D (26)	Clinical report	Implant Direct	None	Counterclockwise rotation of a festooned #557 bur with only end cutting blades in a slow speed handpiece. After exposure of the fragment, clockwise rotation with a #33 1/3 bur to rotate the fractured screw fragment completely out of implants
11.	Shah K et al. (27)	Clinical report	Unspecified	None	Fractured screw was small and retrieval methods damaged the inner thread of one of the implants. A custom laser-welded (LM-D60);BTI Laser) Locator abutment was fabricated and luted into the screw channel with a dual-polymerizing resin cement.
12.	Yoon JH et al. (28)	Clinical report	Internal hex type implant	Surgical microscope	A #329 tungsten carbide bur used to make access hole in centre of the broken screw. The customized drill guide was fabricated using an implant impression coping. The broken screw was pulled out with the reverse tap drill designed to have a cutting blade with a counterclockwise spiral thread using wedge effect.
13.	Carneiro Tde A et al. (2)	Clinical report	SIN/ external hexagon implant	None	A 1.6 mm helicoidal drill used in the fractured screw. The implant internal were re-tapped using a re-tapping tool using rotating motion
14.	Chen JH et al. (17)	Technique demonstration	Straumann	None	Dried the screw fragment and placed an adhesive dental restoration on the top of the fragment, which was rotated one-quarter turn clockwise first and in a counterclockwise direction, screw retrieved with curved haemostat
15.	Yi Y et al. (29)	Case series	Hexplant (6 implants)	None	Patient 1(2 implants)- 1 screw was removed by explorer and the other screw was not retrievable, a cut screw (3.2mm; 6.5 threads) was placed over after pushing the fractured screw down. Patient 2 (3 implants) – 2 screws were removed by counterclockwise rotation with an explorer and an ultrasonic scaler, the other screw was non retrievable so a new screw was cut to the length (2.15mm; 3.5 threads) on the upper part of fragment. Patient 3(1 implant) – A new cut screw (2.6mm, 4.5 threads) was placed on the irretrievable screw fragment

Tab. 1B Characteristics of studies included in the systematic review

S.No	Author and year	Type of study	Name of Implant/ Type	Accessibility tool	Method
16.	Zeng K et al. (30)	Technique demonstration	Unknown	None	The abutment shank is measured with a caliper and appropriate microtube and K-file is selected. The microtube wraps around the head of fractured abutment screw and the small gap between them is fitted and wedged with a K file. The K file is turned clockwise to tighten it. The microtube and K file assembly is rotated counterclockwise.
17.	Cheng FC (11)	Clinical report	Ankylos, Dentsply Sirona Inc	None	A groove of a sufficient depth was made with straight fissure bur on the fractured screw surface and then a counter-torque screw retrieval device was used to remove the fractured screw fragment out from the implant by counterclockwise screwing action
18.	Bai X et al. (10)	Clinical report	Nobel Biocare	Loupes	A small 1.2 mm round tungsten carbide bur driven at a slow speed using an electric motor was used to separate the screw head from the shank under magnification. The residual screw fragment was then unscrewed using a hemostatic (Straight Kelly-Rankin;HuFriedy)

Tab. 1C Characteristics of studies included in the systematic review

at the junction of the screw head and the shank or at the junction where the threaded section begins. The level of the fracture determines the ease of retrieval. If the fracture is above the implant platform, then hand instruments can be used to retrieve the fractured screw. In case the fracture is below the implant platform then it becomes very difficult to retrieve because of thread deformation(30). Deformation of thread may impede the rotation of screw fragment. Metal debris during the removal process may fall into gaps and cause the retrieval difficult. The remaining fragment should be retrieved without damaging the internal threads inside the screw access channel of the implant. Considering the various therapeutic circumstances in which these fractures occur, successful retrieval necessitates accuracy, ingenuity, and adaptation(10,11,12,13).

Modern techniques have altered the recovery of broken abutment screws, improving accuracy and success rates of these difficult procedures by providing increased visual skills and assisting in the exact retrieval of shattered screw fragments, dental surgical microscopes have developed into indispensable instruments(14). Cone-beam computed tomography (CBCT), computer-aided design and computer-aided manufacturing (CAD-CAM) systems, and other cutting-edge tools and imaging modalities are being used in recent developments, such as the screw shank for retrieval, exemplify the successful integration of technology and implant dentistry, streamlining procedures and showing the innovative problem-solving ability of technology in tackling difficult clinical difficulties and raises success rates. The creation of heat has become a problem during the removal of broken abutment screws, and it could have serious consequences. Excessive heat can damage the implant and the tissues around it, which can lead to difficulties(15,16).

The objective of this systematic review was to evaluate in detail the challenges posed by broken implant-abutment screws and the wide variety of methods employed to remove them from screw- or cement-retained implant-supported prostheses. The review aims to provide insights into the efficacy, safety, and clinical applicability of these various approaches, helping to better patient outcomes in the field of implant dentistry by critically reviewing and synthesizing available literature.

METHODOLOGY

The retrieval of fractured abutment screws from screw- or cement-retained implant-supported prostheses was the main topic of the thorough search for pertinent studies. To ensure a thorough and systematic approach in line with the study's particular area of focus in implant dentistry, it involved the use of specified keywords and controlled vocabulary (MeSH terms) across databases including PubMed, Scopus, Web of Science, Google Scholar and Cochrane. The search approach included terms like "Cement Retained Implant Prosthesis", "Screw Retained Implant Prosthesis", “Dental Implant

Screw", "Abutment Screw," "Fractured Abutment Screw," "Broken Abutment Screw," "Abutment Screw Retrieval" and "Abutment Screw Extraction." This extensive set of search criteria made sure that a wide range of pertinent publications covering many aspects of abutment screw retrieval were found, which added to the systematic review's completeness and comprehensiveness.

The databases used for the search were PubMed, Scopus, Web of Science, Google Scholar, and Cochrane which are recognized for containing a wide range of research publications on medicine and dentistry. Only English-language articles were included in the search restrictions. The search was focused on articles published within the time frame of 2010 to October 2023.

A total of 86 items were found in the initial search. To find papers that matched the goals of the research, the abstracts of these articles were carefully examined. Out of the total number of articles searched, only 18 studies were included in the present systematic review, which was on par with the inclusion criteria of the study. After the initial database search, duplicate records were removed. Two independent reviewers (SB and TB) then screened the titles and abstracts of the remaining studies based on the inclusion and exclusion criteria. Full texts of potentially eligible studies were retrieved and further assessed for eligibility. Any discrepancies were resolved through discussion or consultation with third and fourth reviewer (AD and PP) when necessary.

PICO Framework

Population (P)- Patients with dental implants who have fractured abutment screws were the population. Intervention (I)- Several techniques, methods, devices that were used to remove broken abutment screws from dental implants. Comparisons (C)- Comparisons was made between various screw retrieval methods, devices, or strategies. Outcomes (O)- The success rate of removing abutment screws, the frequency of issues or unfavourable incidents during or following the screw extraction procedure, patients satisfaction following screw removal and comparison of results between various extraction techniques. These well-crafted PICO questions form the basis for methodically analysing the pertinent literature and deriving insightful conclusions on the removal of broken abutment screws in implant dentistry.

Eighty-six studies were initially chosen from Cochrane, Pubmed, Scopus, Web of Science and Google Scholar databases. After identifying and eliminating duplicate studies, 56 studies were screened for further evaluation, 32 studies were sought for record retrieval, 23 studies were assessed for eligibility and only 18 publications with full texts were included in the systematic review.

Inclusion criteria were clinical reports, clinical case series on implant-abutment screw fracture and management while exclusion criteria were finite element analysis studies, reports on stripping of abutments screws and reports on abutment screw loosening. Clinical reports, dental technique demonstrations, current research on patients with fractured abutment screws in dental implants, and English-language publications published between 2010 and October 2023 all met the inclusion criteria for this systematic review. Studies examining various extraction methods, success rates, post-extraction results, patient satisfaction, and comparisons between various methods or prostheses were considered for the review. Studies that were not in English, were not from peer-reviewed sources, did not deal with broken abutment screws, or did not have relevant results or subject matter were all excluded. The subsequent facts were taken from the chosen studies: authors' names, publication year, name of implant and type used, accessibility tool and methods used in the studies. To provide a uniform and open reporting approach, the systematic review adhered to a methodology in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) declaration. A meta-analysis was not conducted due to potential lack of homogeneity in the clinical studies making meaningful amalgamation challenging (Table 1A, 1B, 1C). The systemic review process has been registered under registration number CRD42024519895 at the National Institute of Health & Care Research, International Prospective Register of Systemic Reviews database.

RESULTS

A total of 86 studies identified from 5 databases were screened, after careful selection 18 studies were selected for systematic review following PRISMA guidelines. Of 18 studies, 14 were clinical reports, 1 was case series and 3 were technique demonstration. In all these papers 31 broken screws were reported (Fig. 1). Using a variety of techniques and approaches, most authors (62.5%) removed fractured screws using rotatory burs and handpieces. Remarkably, only twenty-five percent of the experiments used magnification during retrieval. The summary of the data derived from the selected studies is given in Table 1A, 1B and 1C. The majority (10) (62.5%) of authors used rotatory burs and handpiece for broken screw removal. Most common bur used was round bur (3), tungsten carbide (2), followed by straight fissure, helicoidal drill, tapered fissure (each 1) burs. In two reports, type of bur used was unspecified. Five studies used ultrasonic tip in conjunction with rotatory burs, one study used solitary ultrasonic tip to remove screw fragment. Other methods used to retrieve screw fragments were fragment fork and retap screws (2 studies) reverse scissor tip (1 study), endodontic instrument (1 study). In three studies which included 6 clinical cases, screw was not retrieved by any of the

above methods. Only 4 (25%) use any magnification for retrieval. In all these four studies screws were successfully retrieved.
Overall, 31 broken screws reported in studies in which the manufacturers of 25 implants were identified. Highest number of broken implant was reported in Spline Zimmer (7), Hexplant (6), Implant direct (4), Branemark Tiunite (2), Nobel Biocare (1), SIN (1), Ankylos (1), Dentsply Sirona Inc (1), Astra Osseospeed (1) and Straumann (1) companies. In two of the studies screws were not retrieved in those custom abutments of dowel were used to fabricate the crown.

DISCUSSION

Abutment screws are essential parts of implant dentistry. They come in a variety of sizes and shapes and are made of gold, commercially pure titanium, and coated titanium alloys, among other materials. The "galling" effect, which is typified by high friction between contacting metal parts, is particularly countered by gold screws(19). The thread, located at the most apical portion, engages the implant's internal mating surface to produce the desired force, known as preload(4,5,6). This preload depends on several variables, including surface roughness, applied torque, screw material, design, and yield strength. When initial torque is applied, only contact between the microscopic defects on the initial surface of a new metal screw is made possible. Screw settling, or the progressive wear and flattening of these imperfections, is a factor in the gradual loss of the initial preload. Furthermore, additional loss of screw preload might be caused by the cyclic stress and damping effect during occlusal function, which will ultimately result in loosening. The risk of screw loosening or breakage is increased when screws are overtightened, as this can lead to plastic deformation and consequent loss of preload. Since screw loosening frequently occurs before screw fracture, it is essential to repair loosened abutment screws as soon as possible(7,8,9). Screw loosening is more common in external hexagon implant configurations than in other connection designs, as evidenced by prospective studies. Pre-molars and molar sites for single-tooth restorations had a 7% prevalence of abutment screw loosening. To counteract this, it has been suggested to retighten the screw five to ten minutes after applying the initial tension, making sure that the torque is sufficient to prevent further loosening. Compared to uncoated screws, coated screws exhibit better preloads for a range of insertion torques and tightening situations(2,3,10,12). In implant dentistry, retrieving fractured abutment screws is still a major difficulty. Systematic evaluations that highlight sophisticated extraction techniques which include cutting-edge technologies like cone-beam computed tomography (CBCT), dental surgical microscopes, and computer-aided design and manufacture (CAD-CAM) systems have improved patient outcomes. The precision and success rates of retrieving shattered abutment screws are greatly improved by these improvements(13).
Numerous studies have demonstrated the revolutionary influence of cutting-edge technology in the field of implant dentistry, including those by Patel RD et al. (2010)(13), Azpiazu-Flores FX et al. (2020)(14), Maalhagh-Fard A et al. (2010)(20), and Imam AY et al. (2014)(24). These technologies have enabled professionals to carry out complex operations with unmatched accuracy, which represents a breakthrough in the field.
The risk of thermal injury to bone has been highlighted, and crucial benchmarks have been identified as threshold temperature-time profiles. Potential bone injury is linked to temperatures above 47 degrees Celsius for one minute, 50 degrees Celsius for thirty seconds, and 56 degrees Celsius for any length of time. Because titanium has a poor thermal diffusivity, it is difficult for generated heat to dissipate, hence methods for reducing heat generation during the removal of broken abutment screws must be used. The need to use heat-reduction techniques to guarantee patient safety and positive results has been highlighted by Arias SR et al. (2018)(16). This is because too much heat can damage the implant's structural integrity as well as the tissues around it. Moreover, the decision regarding implant-supported prostheses that are screw -or cement- retained has a substantial effect on the frequency of abutment screw fractures. The thorough systematic study carried out by Mizumoto RM et al. (2018),(31) Ortega NM et al. (2023)(32), and Hamed MT et al. (2020)(15), goes thoroughly into the consequences of each retention strategy, highlighting the significance of taking retrievability, biomechanics, and aesthetics into account. Informed clinical decision-making and the prevention of abutment screw fractures depend on an understanding of the benefits and limitations of each therapy.
The wide range of clinical situations that arise in implant dentistry emphasizes how important it is to have customized strategies that take certain contextual elements into consideration. As explained by Bai X et al. (2023),(10) Cheng FC et al. (2023)(11), and Nayana P et al. (2022)(1), a thorough grasp of the range of abutment screw fractures highlights the significance of keeping a flexible toolbox of retrieval techniques to successfully handle the different kinds of fractures that arise. Conserving the implant and the surrounding anatomical tissues requires a conservative approach, as suggested by Carneiro Tde A et al. (2016)(2), Vakou D et al. (2021)(33), and Yi Y et al. (2021)(29). This patient-centred approach promotes a thorough and cautious abutment screw removal procedure to minimize possible damage and maintain the implant's structural integrity.

The continuous improvement of retrieval methods is necessary as implant dentistry develops. The industry's dedication to innovation as a way of effectively resolving issues is exemplified by the introduction of several supplemental processes for intraoral removal of fractured implant-abutment screws by Chen JH et al. (2018)(17), Lee MS et al. (2023)(34), and Shah K et al. (2016)(27). These developments highlight the field's focus to improving patient outcomes in addition to demonstrating a commitment to problem-solving. The industry's unwavering commitment to innovation is a key factor in the advancement of implant dentistry.

As demonstrated by Gooty JR et al. (2014)(3), Shedmake S et al. (2022)(35), and Yoon JH et al. (2016)(28), novel non-invasive procedures have greatly improved patient comfort and safety while recovering fractured dental implant-abutment screws. These advancements highlight the field's continued commitment to creating retrieval techniques that are both minimally disruptive and successful, with a focus on patient well-being. The imaginative use of the screw shank as a retrieval tool by Azpiazu-Flores FX et al. (2020)(14), is a prime example of the vital role that creative problem-solving plays in the field of implant dentistry. Furthermore, the studies by Raju S et al. (2021)(36), Nayana P et al. (2022)(1), and Cheng FC et al. (2023)(11), highlight how adaptable and creative clinicians can be when faced with difficult circumstances. These studies emphasize the need of adaptability and originality in coming up with workable solutions for complex retrieval scenarios, emphasizing the crucial part that creative methods play in producing positive results. Additionally, Zeng K et al. (2022)(30) have presented a method for implant screw retrieval using the endodontic microtube extraction device, demonstrating the creative application of specialized instruments to difficult retrieval problems. Similarly, Lee MS et al. (2023)(34), recommended using an 18-gauge syringe needle together with a specially designed screwdriver that has two, three, or four claws. The need of making exact modifications to the claw size to guarantee the best possible gripping for successful retrieval is emphasized in their report. The collective results highlight the implant dentistry community's continued dedication to utilizing creative thinking and cutting-edge methods to overcome obstacles and improve patient outcomes. If none of the methods worked and the patient refused to give up the implant, a laser-welded or specially cast post and core made of nickel or cobalt-chromium alloys might be created and inserted into the implant(36,37,38).

This systematic review emphasizes the importance of technology advancements, careful retention method selection, heat control during retrieval, customized clinical techniques, preservation of implants, ongoing innovation, a range of clinical challenges, effective categorization of abutment screw fractures, and non-invasive retrieval approaches to properly address fractured abutment screws. By providing incisive details on therapeutic strategies, it highlights the need for precision, flexibility, and patient-centred treatment. More research is necessary to advance the field and improve patient outcomes in implant dentistry. Advantages are comprehensive knowledge of the various extraction methods, empowered decision-making on the part of practitioners and an emphasis on patient-centric strategies and technological integration. Limitations are potential biases and contradictions that may exist in the literature currently in use, direct comparisons are challenging because of different approaches, generalizing findings from various study designs is difficult and more empirical study is required to fill in the gaps found.

CONCLUSION

The wide range of uses of implant dentistry is demonstrated by treating cracked abutment screws while clinician should follow guidelines to prevent such screw fracture in first place. Important retrieval elements are emphasized in this analysis, with a focus on modern technology integration, cautious retention techniques, and efficient heat management. When combined with customized clinical procedures, the application of a classification system for abutment screw fractures allows for accurate and patient-centred therapy. Setting non-invasive retrieval techniques as a top priority to prevent any damage to implant's internal structure and maximizing safety of the patient. The removal strategy is also guided by the experience of the clinician and location of the fractured screw in patient's mouth. The review does, however, note certain limitations, such as possible biases, methodological differences that make direct comparisons difficult, and difficulties extrapolating results. To get over these obstacles, research and development must be continuously prioritized so that problem can be solved without trial-and-error method. Standardizing practices, carrying out comparative efficacy studies, and filling in the gaps through empirical research should be the main goals of future studies. To help practitioners and academics, a focused call for future research fields is necessary, with an emphasis on patient-reported outcomes, comparative efficacy, and standardised approaches. In general, further research into innovative methods and technology developments is necessary to improve implant dentistry and the retrieval of shattered abutment screws.

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