A Conservative Technique for Fractured Implant Abutment Screw Retrieval on an Internal Connection Implant: Proof of Concept

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Broken screw removal from the implant connection is a common but challenging process. Several proposed methods and technical solutions may result in unsuccessful removal; thus, a novel, more conservative, risk-free method is proposed as a first attempt. The proposal is to use a silicon restoration holder to be twisted counterclockwise on the dried surface of the broken fragment inside the implant connection. This method, within the limitations of a minimal case series, yielded 100% results; however, despite previous attempts with less conservative techniques, this approach showed no efficacy. This article aims to promote the use of silicon restoration holders as a minimally invasive first attempt at broken screw retrieval treatment before considering other options.

Key Words: abutment screw, screw fracture, screw retrieval, adhesive holders, clinical case letter

INTRODUCTION

Even if implant treatments are a safe and predictable way to replace missing teeth, patients are not free from complications. Several articles address this issue, but over time, different implant designs and prosthetic solutions have been developed; thus, summarizing a joint assessment among the authors is complex. However, 2 main categories of possible problems can be recognized: biological and mechanical. A systematic review led by Goodacre et al revealed that many mechanical issues have been reported in the literature. Abutment screw fractures are among the least common occurrences (2%).[1] Despite this minimal percentage, considering the millions of implants placed every year around the globe, the prevalence of fractured screws encountered is anything but small, representing a common unpleasant situation for a considerable number of clinicians.

According to the earliest reviews on this topic, there needs to be a standardized protocol to approach these problems. For this reason, several algorithms based on the available knowledge have been proposed. The logic behind them is to encourage a clinical approach that starts with the most conservative techniques before considering drastic solutions, such as implant removal. The fracture above the implant platform increases the difficulties in fragment removal, representing the first important crossroad in this decisional path.[2,3] Moreover, fractures are not always perpendicular to the screw axis; in fact, an oblique break line could represent an opportunity to try minimally invasive techniques because the instruments have a better grip. In this situation, it is also possible to apply very conservative methods that permit this broken fragment surface geometry to be more effective. A clinical case report involved using a cotton swab, which was shortened enough to be positioned vertically as a screwdriver inserted into the implant head and twisted slowly counterclockwise with light pressure.[4] In addition, as a popular recommendation, which does not have any literature support, older implantologists use broken wood sticks to create a rough wooden surface, which may provide enough friction to apply an unscrewing torque. Unfortunately, no data are available to assess the reliability of this technique. Instead, when a perpendicular fracture occurs, an attempt to retrieve the screw by using a probe and twisting it counterclockwise might be successful.[5] Then, the conventional method, which consists of applying an ultrasonic tip on the fragment twisted simultaneously with a probe, is suggested. It is economical and supported by the statistical data showing an extraction success rate of 73.3%. In the same in vitro study, this effectiveness is compared with that of retrieval kits (Broken Screw Extractor Kit, Rhein83), which resulted in a more significant percentage of success (96.7%). All 60 implants had internal hexagonal connections (Kohno, Sweden & Martina).[6] There are other different

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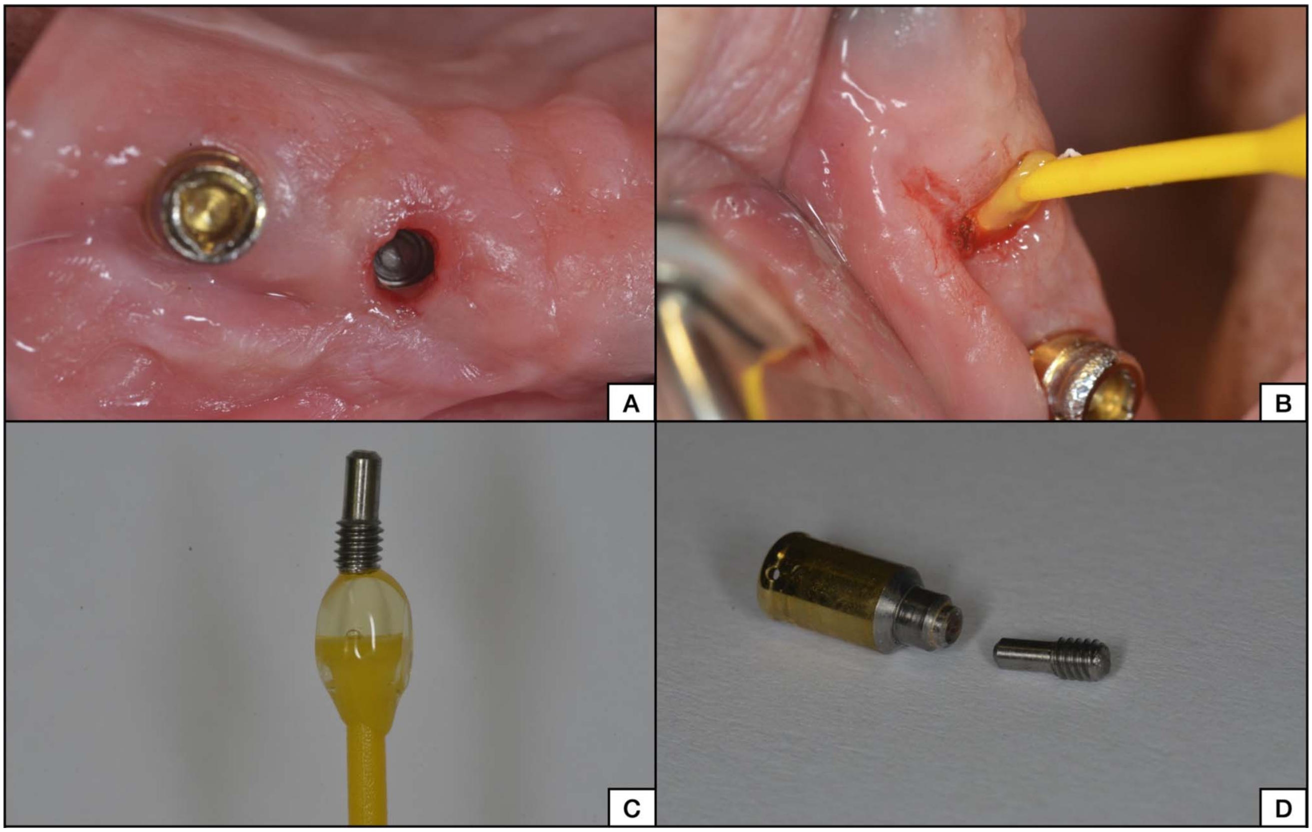

Figure 1. (a) Occlusal view of the broken fragment inside the implant connection. (b) A restoration holder was applied to the fragment surface before twisting it. (c) The retrieved fragment was cleaned and positioned on a clean new holder. (d) The broken screw next to the overdenture attachment.

kits available on the market (ITI Dental Implant System, Institute Straumann AG, Switzerland; IMZ TwinPlus Implant System1, DENTSPLY Friadent, Germany; Screw Removal Kit Replace, Nobel BiocareTM, Yorba Linda, CA; Certain Screw Removal Kit, Biomet *3i*TM, FL) following almost the same idea of using a centering device that allows a bur rotating counterclockwise in the middle of the fragment head to be engaged and twisted out of the connection, avoiding (as much as possible) internal structure damage. It must be considered that irrigation cannot reach the working surface with this device. Moreover, the complete stability of the handpiece on the centering device is challenging because of the reduced support surface on the head of an implant. Before trying such a risky technique, Yang et al suggested using a screwdriver fashioned from a needle as a solution.[7] When all of these solutions fail, screw or even implant modifications are needed with a higher risk of damaging internal threads.[8] This article aims to present a series of clinical cases in which the use of only adhesive restoration holders allowed the possibility of retrieving screw fragments from internal connections in a completely conservative and biologically safe way.

Description of the Cases

In the present article, clinical cases in which 5 screws were removed with the proposed method are documented; these cases are shown on a 30° internal conical connection. In the first case, the broken screw is removed as part of an overdenture attachment positioned on an implant in the premolar area of the left maxilla in a 54-year-old woman (Figure 1). After that, in the following image sequence, the screw is removed from the connection of an implant in the second premolar on the right side of the mandible in a 30-year-old man (Figure 2). In the end, the most striking case is represented by a 63-year-old woman's mixed bridge (teeth and implants), in which 3 fragments in a row are removed from the implant-prosthesis connection (Figure 3). The reasons behind these events is not always clear. Nevertheless, some assumptions can be made. For example, having long supra-implant components (Figure 1d) could be a risk factor,[9] especially with lateral forces in the posterior areas. It is highly possible that the mobility of the periodontal ligament of the natural element retaining the prosthesis stressed the abutment screws of the implants connected to the same structure leading to multiple complications (Figure 3b). Finally, it is more difficult to identify the probable reason in the second case. Seeing the top of the fragment slightly below the implant platform (Figure 2a), it is possible that screw loosening occurred before with occlusal forces leading to this situation. Less torque is needed during the treatment compared with the others. However, the exact amount of force applied is not detectable objectively. In each of the 5 fragments, the fracture is below the implant platform perpendicularly to the screw's long axis. The break line is always coronal to the first thread. The instrument used to apply this technique is a plastic stick with a silicon tip used to hold dental veneers during cementation procedures. On one side, a silicon tip firmly adheres

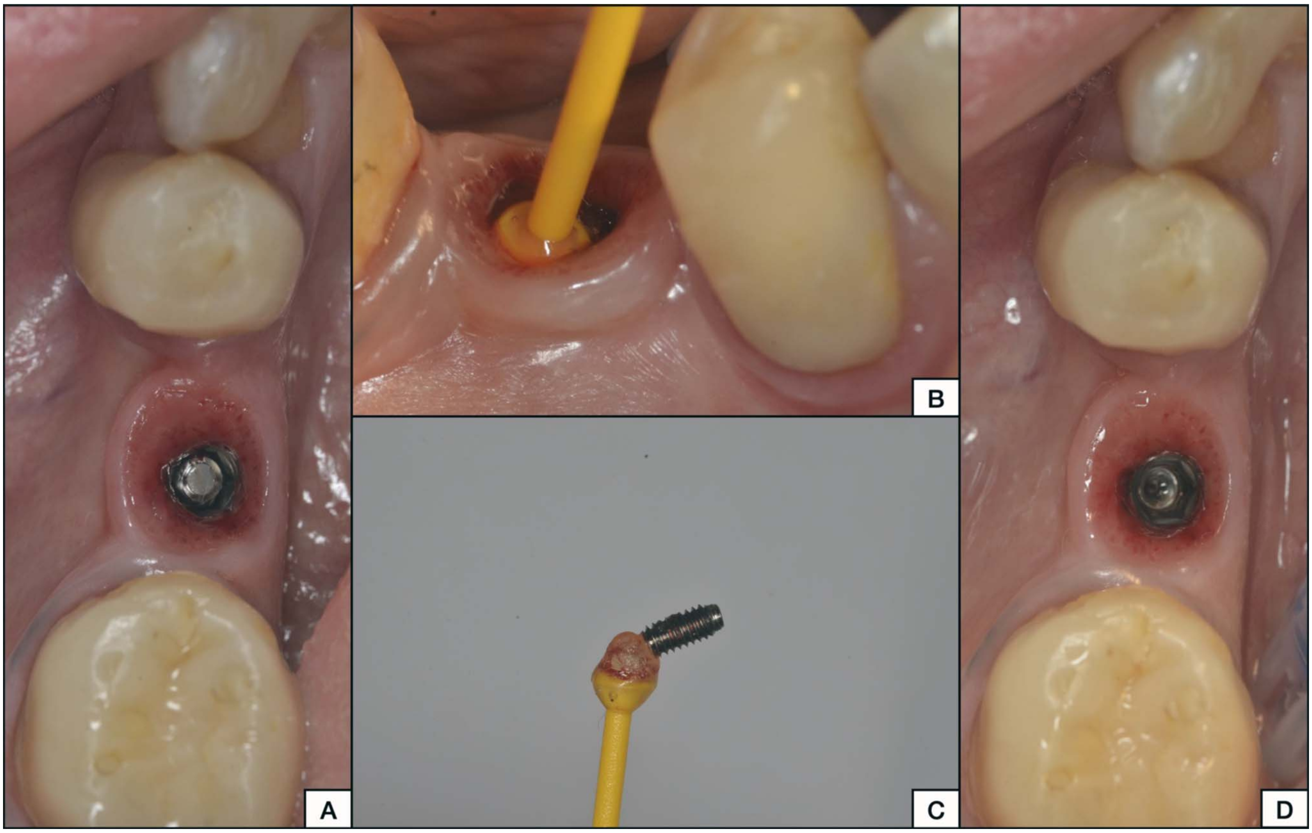

Figure 2. (a) Occlusal view of the broken fragment inside the implant connection. (b) The restoration holder is applied to the fragment surface before twisting it. (c) The fragment is on the holder just after the retrieval. (d) Occlusal view of the implant connection freed from the broken screw.

to dry surfaces, and its characteristic is not to leave residues when removed; nevertheless, it has relatively strong adhesion. It must be applied perpendicularly on a dry surface, possibly rotating it counterclockwise. Oil-free compressed air minimizes the fluid's return if blood or saliva contaminates the top of the fragment before the restoration holder is applied as quickly as possible. If this happens, the bond strength between the tip and the metal decreases. Especially in posterior areas where access is reduced, the stick can be modified by folding it or cutting it at the length of a screwdriver as Barbosa et al did with the cotton driver method described previously.[4] Whenever a loss of grip is felt, it is recommended to change the instrument and repeat the steps until clinical success is achieved (Figures 1 through 3). At least 4 or 5 sticks are needed in the authors' experience. Changing the instrument is also essential when the clinician feels that silicon twists on itself due to the forces applied, assuming a rounded shape, which is the previous step for removing the material from the plastic stick. If this happens, it may fall into the patient's mouth and can be aspirated or swallowed. According to the authors' experience, another event, although very rare, is the possibility of losing the material in the deep submucosal planes if a mucoperiosteal flap is elevated. Furthermore, bleeding could represent a problem, especially in 2 situations: when a gingivectomy must be previously performed due to keratinized tissue growth over the implant if the structure gets covered or when opening a flap is needed. Using anesthetic solutions combined with adrenaline could help control this complication due to its vasoconstrictor activity, increasing visibility[10] beyond discerning the silicon tip bond with the metal. The authors report that the only case of failure with this approach was probably spoiled by the previous attempt of a clinician to remove the screw with an ultrasonic tip, which probably damaged the internal threads, making it impossible to remove it later with the restoration holder. The causes of these complications are not explored in the present report because they did not correspond to the article's aim; nevertheless, clinically, biomechanical failures need to be inspected for their causes.

Moreover, it is not possible to trace data about the design of the implant abutment screws, such as their diameter. The limited number of cases investigated does not provide the statistical significance or the possible influence of these aspects on the type of fracture or the effectiveness of the technique.

Written informed consent was obtained from each patient enrolled in this report regarding the anonymous use of the clinical photographic documentation for scientific purposes.

Discussion

When a perpendicular screw fracture occurs below the implant platform, the techniques proposed in the literature to retrieve the fragment pose a certain risk of internal connection damage that varies from mild to severe. Even ultrasonic oscillation combined

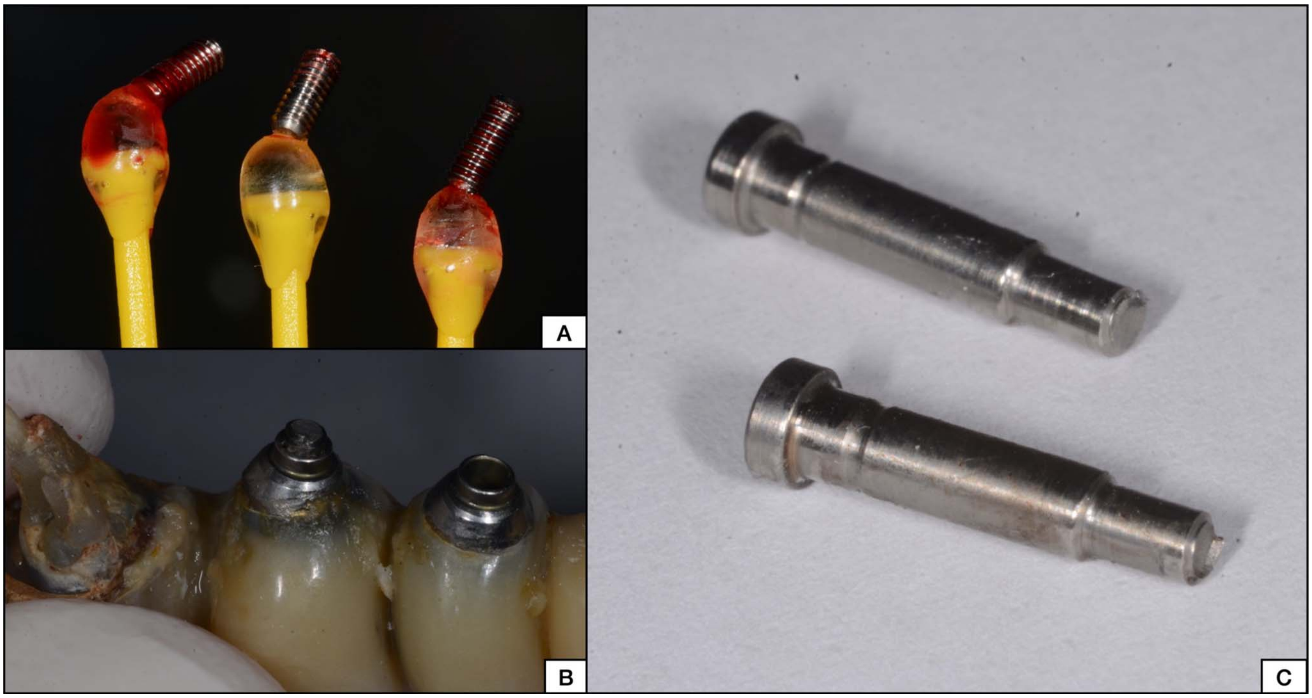

Figure 3. (a) Three fragments were retrieved in a row, each on the respective holder. (b) The view of the apical part of the mixed bridge removed from the patient's mouth. (c) The upper part of 2 of the broken screws.

with hand instruments is reported to produce, although minimal, damage to the implant surface, such as abrasion.[11] This is possible for more than one reason. First, an explanation could be found in the so-called "galling," which is one of the biggest problems associated with titanium retaining screws. If their surface slides on the implant body metal, particles transfer from one side to the other, damaging both structures.[12] It is speculated that this could occur even due to fragment micromovements caused by oscillating instruments during removal. Moreover, the titanium used to produce implant bodies is not chemically pure because of its low prolonged stress resistance and poor suitability for fine processing. The most used one is called commercially pure titanium (CP-Ti). It is classified into 4 grades of decreasing purity due to traces of contaminants, which are directly proportional to the mechanical properties.[13] Among these different types of titanium, CP-Ti grade IV is usually the most frequently employed to produce implant fixtures; however, even titanium alloys (TA), such as Ti6AlVa4, are adopted.[14] The choice is based on the fact that, whereas the modulus of elasticity remains almost stable, ranging from 102 GPa for grade I CP-Ti up to 113 GPa for TA, the yield strength of the first one, if compared with the latter and CP-Ti grade IV, is, respectively, 5 and 3 times lower.[15] TA is mainly used for abutment retaining screws due to its higher resistance compared with the other types of titanium to reduce the risk of deformation and fracture under loading pressures;[12] therefore, it is logical to think that the mechanical action of the instruments, working between 2 materials characterized by different structural behaviors, can deviate by being more active toward the weakest one. In this case, it is the implant body whose internal integrity gets permanently compromised. However, it is clinically challenging to direct ultrasonic action only on the fractured screw instead of the internal threads on the sidewalls of the connection or the residual exposed threads in the empty coronal region over the fragment head. When ablation energy is applied to these average 350-micron traditional V-threads, permanent modification may occur, preventing any further possibility of unscrewing. Although this shape is widespread, it is not the only one. Spiralock (registered trademark of Spiralock Corporation) is a design that incorporates all BioHorizons implants and features a unique 30° wedge ramp at the root of the thread that locks the abutment screw to the implant. A conventional V-thread abutment screw is axially loaded, whereas a Spiralock thread distributes the load radially. This uniformity reduces the forces and stress concentration at the first engaged thread, significantly increasing the strength of the connection and preventing fatigue failure. On the other hand, this shape could represent an obstacle during fragment retrieval because the tip of the screw threads goes coronally due to increased friction. Among all the methods described in the literature, Chen et al in 2018[8] are the only ones describing the use of adhesive restoration holders to retrieve broken screw fragments. However, it can be considered completely conservative only if the fragment is already loosened and the coronal region is slightly above the connection, and these are prerequisites for the adhesive tip to be effective in that article. Otherwise, the use of ultrasonic tips and hand instrumentation is needed; alternatively, modifying the screw or even the implant is considered necessary. Ultimately, it is possible to say that, in that technique, the restoration holder is used to ensure that the screw is almost retrieved. In contrast, this previous step was not necessary in the method adopted in this article. It is also worth noting that the approach proposed results were effective besides the fractures reported to be below the implant platform and perpendicular to the long axis of the screw. Moreover, greater respect for internal connection structures seems to be guaranteed beyond a success rate. Nevertheless, it is supposed that previous attempts could reduce the possibilities to have positive outcomes. In fact, in the authors' experience, it has proven to be a sufficient reason to make this technique fail in this specific situation. However, the extent of the damage that made removal impossible was not assessed. Unfortunately, photographic documentation of these clinical cases is unavailable. Additionally, the cost of the restoration holders is not irrelevant, considering that more of them are needed to obtain a positive result in a manner directly proportional to the clinician's inexperience. Inspired by this device, a more ergonomic one should be designed to reach posterior areas where interocclusal space is limited. Most likely, an angulated or short instrument used with repeated winding movements—with the possibility of ensuring that the device is on the finger and preventing it from falling and being aspirated or swallowed by the patient—could be suitable. In the end, it is possible that the screw design and diameter could have influenced the fracture occurrence, type, and location beyond the clinical outcome of the treatment. Despite that, it was not possible to trace this data. Regarding this, it must also be said that the limited number of the sample could have led only to mere suppositions. Considering this approach's limitations, it could be the best option to try initially based on decisional trees proposed by different search teams that suggest starting with noninvasive treatments before attempting more destructive treatments. However, further research is needed to evaluate the impact of operator experience on the duration and number of holders used as well as on the effectiveness of the treatment. More randomized studies comparing the latter with other methods proposed in the literature should also be carried out to evaluate the damage caused by each of these methods toward the internal connection of the implant. The mentioned use of the adhesive restoration holders may represent an effective, economical, and conservative first attempt approach for removing failed implant abutment screws. Comparable techniques for the instrumentation used for noninvasive purposes do not seem to be equally independent of other previous steps or fairly effective when fractures occur below the implant platform. Trying to remove fragments, even with the most conservative approach proposed in the literature, such as ultrasonic tips, could damage the internal threads, decreasing the possibility of successful treatment. It is desirable to obtain further data to compare the technique with the others statistically; moreover, testing for operator-dependent factors should be considered.

Note

The authors declare that they have no competing interests.

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