Journal of Taibah University Medical Sciences (2020) 15(5), 431–436

Taibah University

Journal of Taibah University Medical Sciences

www.sciencedirect.com

Case Report

Management of an over-extruded fragment in a C-shaped root canal configuration: A case report and literature review

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Received 25 March 2020; revised 22 June 2020; accepted 1 July 2020; Available online 26 July 2020

الملخص

يُعتبر انكسار الأدوات اللبية من الحوادث الشائعة أثناء معالجة الأقنية الجذرية. يعد التكوين المُعقّد لأنظمة الأقنية الجذرية هو العامل الأكثر تأثيراً، ليس فقط على حدوث انكسار الأدوات، ولكن أيضا في علاج مثل هذه الحوادث غير السارة. هناك عدد قليل من التقارير حول علاج الأدوات المكسورة في الثلث الذروي من الأقنية الجذرية، خصوصاً تلك الممتدة خارج الذروة. تمت إحالة مريضة عمرها 37 عاماً إلى اختصاصي علاج جذور الأسنان من أجل إكمال علاج الأقنية الجذرية بعد انكسار مبرد في الثلث المتوسط من قناة الجذر المُكوّن على شكل حرف (C) في الرحى الثانية من الفك السفلي. أدت المحاولة الفاشلة لتدبير الجزء المكسور من قِبل طبيب الأسنان المُحول إلى دفع الجزء المكسور إلى الذروة وإمتداده جزئياً إلى خارج الثلث الذروي. تم إزلة الأداة المكسورة بنجاح وأمان بواسطة إجراءات وتقنيات مختلفة بما في ذلك؛ تجاوز الأداة المكسورة، وقلقلتها بالموجات فوق الصوتية ومن ثم إزالتها بواسطة ملقط مجهري على شكل مخلب السلطعون (مجموعة إزالة الأدوات المكسورة من زوماكس). يظهر تقرير هذه الحالة أهمية التكبير العالي الذي توفره المجاهر السنية الجراحية، والمهارات السريرية والقرارالسليم، خاصة لتقييم صعوبة الحالات التي تستلزم طرق علاج مختلفة. أضف إلى ذلك، فإن توفر الأدوات المختلفة في علاج الأدوات المكسورة يُعتبر أمراً أساسياً. أخيراً، يقترح ويدعو تقرير هذه الحالة إلى استخراج الأدوات المكسورة والممتدة خارج ذروة السن من دون تداخل جراحي.

الكلمات المفتاحية: منفصل؛ مكسور؛ ممتد إلى الأعلى؛ الموجات فوق الصوتية؛ استئصال

Abstract

Separation of root canal instruments is a common incident during root canal treatments' procedures. The complex configuration of root canal systems is one of the most influencing factors, not only during the occurrence of instrument separation but also during the management of such unpleasant incidents. There are few reports on the management of fractured instruments located in the apical third of the root canals apical, especially those extruded beyond the apex. A 37-year-old woman was referred to an endodontic specialist to complete a root canal treatment after the separation of an endodontic file in the middle-third of the C-shaped root canal configuration (Vertucci type II) of the mandibular second molar. A failed attempt at managing the fragment by the dentist resulted in the backward placement of the fragment, which was more apically, and partial extrusion beyond the root apex. The fractured instrument was successfully and safely retrieved using different procedures and techniques including bypassing the fragment, loosening the fragment using ultrasonics and then removing it by the crab-claw shaped tweezers (Zumax broken instruments removal kit). This case report demonstrates the importance of high magnification provided by the dental operating microscopes and sound clinical skills and judgment, especially in assessing the difficulty of cases that is necessary for various treatment approaches. In addition, the availability of different armamentaria to manage separated instruments is essential. Finally, this case report proposes and advocates the idea of removing fractured instruments extruding beyond the apex without surgery.

Keywords: Fractured; Over-extruded; Removal; Separated; Ultrasonics

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Peer review under responsibility of Taibah University.

Production and hosting by Elsevier

 https://doi.org/10.1016/j.jtumed.2020.07.001

Introduction

Prior knowledge of root canal anatomy facilitates effective cleaning and shaping of the root canals system, which is essential for successful endodontic treatments.[1] One common example of complex anatomies is a so-called C-shaped root canal configuration in which root canals are connected by a web with anatomical changes along the root. Cleaning and shaping procedures of such configuration is a real challenge. The term "C-shaped" was introduced by Cooke and Cox[2] to describe the cross-section of root canals that appear like the letter C. The complexity of this anatomy makes it difficult to be cleaned, shaped, and obturated tightly. In addition, some complications may occur during cleaning and shaping, such as ledges formations and root canals perforations, which may end up in failure of the treatment. Intra-canals separated instruments are one of the most difficult complications that prevent complete cleaning of the root canals, which subsequently may cause treatment's failure and possibly teeth loss.[3] In addition to the complexity of root canals' configuration, there are several contributing factors that increase the risk of instruments separation such as, overuse of instruments, inappropriate files insertion, and insufficient practitioner experience.[4]

Management of separated instruments can be accomplished through conservative/non-surgical or surgical approaches. The non-surgical approaches are usually the first line of management. These include an attempt at removing the fragment, attempt at bypassing it, or cleaning and filling the root canal to the level of the fragment.[5] Tamse and Katz[6] suggested the use of separated instruments as the final root canal filling based on their four-years of observation. No periapical radiolucency was detected, and the patient was asymptomatic. However, it should be noted that the separated instrument, most of the time, does not play a big role in sealing the root canal. By contrast, the tight coronal sealing and the absence of irritants beyond the level of the separated instrument may increase the success rate.[7] Madarati et al. highlighted two main concerns of retaining fractured instruments, which may affect the long-term treatments outcomes.[5] The metallic segments present within the root canals may undergo corrosion is the first concern. Only one study, with a two years follow-up, showed that stainless steel (SS) segments were inert and did not exhibit corrosion.[8] The authors indicated that this concern needs to be addressed by future studies on both SS and NiTi instruments.[5] The second concern is that the retained fragments most probably compromise effective debridement of the apical portion of the root canal system, which in turn may adversely affect the treatment outcome. This is especially true in teeth that have periapical diseases.[9] Reports reveal lower success rates for cases that had both retained fractured files and periapical lesions at the time of instrument fracture.[9] Consequently, leaving the fragments within the root canals is usually neglected in cases of periapical diseases, hence clinicians and reports suggest surgery, especially when the extension of the separated instrument is periapical.[10] The surgical approaches include apicoectomy, root amputation, or intentional replantation, which may be the last resort to retain the natural tooth before extraction.[11] However, sometimes the surgical approach, especially apicoectomy, may not be applicable, because of the difficulty to access the site, lack of visibility of the surgical site, and its proximity to important anatomical regions, such as the mandibular canal and its neurovascular bundle in the mandible, the maxillary sinus, or nasal fossa in the maxilla. Nevertheless, bypassing the fragment may not be guaranteed, especially when the cross-section shape of the root canals is round, hence there is no space around the fragment to allow insertion of instruments alongside the fragments.[5] Consequently, successful and safe removal of fractured files has been considered the optimum approach.[5] There have been advancements in this area, such as the use of dental operating microscopes with better magnification and illumination, improved designs of ultrasonic tips, and the use of innovative instrument retrieval systems, that have contributed to more predictable removal of broken instruments. Therefore, the affected tooth can be preserved.[5] Consequently, the attempt at removing fractured files is gaining more popularity among clinicians. However, this management is not always successful and has different success rates ranging from 55% to 79%, according to the reports.[12] Many factors affect the success rates, such as the use of techniques, devices and methods, the location of fragments within the root canals and the skills of the operator. One common thing in these reports is the significant low success rates in removing fragments located in the apical third, especially inside and beyond the curvature (58% and 52%, respectively), when compared to those that reported regarding the middle and coronal thirds (68% and 100%, respectively).[3] Moreover, Hülsmann reported successful removal of only 3 instruments out of 6 instruments (50%), which were extruding beyond the apex.[3] In addition, reports showed greater incidents of complications are associated with the management of fractured instruments in the apical thirds, which included weakening the dental structure, ledges formations, perforations, and over-extrude separated instruments beyond the apex.[3,13] Predictably, such cases can be considered the most difficult and challenging ones. Accordingly, clinicians and reports suggest bypassing or surgical approach for such cases.[10]

There is neither sufficient description of therapeutic procedures nor enough case reports on the successful removal of instruments located in the apical third of the root canal system. Therefore, case reports that present a full description on the management of fragments located in the apical third, especially those extruded beyond the root apex, is important.[13] The following case report describes one example where over-extruded broken instruments were managed in a mandibular second molar with a C-shaped root canal configuration. It explains in detail the sequential steps of the procedure according to the challenges faced during the treatment. Therefore, this case study reveals important factors regarding the importance of knowledge, good

armamentaria and clinical skills, and judgment during the procedure of managing such challenging cases conservatively and successfully.

Case report

A 37-year-old female patient was referred by a general dental practitioner for the completion of the root canal treatment after an incident of intra-canals instrument fracture in the mesial canal (in the middle third) of the lower right second molar tooth with a type II root canal system configuration. The dentist tried to bypass the fragment, but unfortunately, it was pushed more apically and ended up with a partially extruded fragment (beyond the root apex). Immediately, the referring dentist stopped the bypassing procedure and sealed the access cavity with a temporary filling. Then, the referring dentist referred the patient to an endodontic specialist and sent the radiographs of the case (Figure 1-A/B). After 48 h, the patient was presented to the specialty clinic with the tooth being slightly symptomatic on percussion. A diagnostic radiograph was taken (Figure 2-A), revealing two-thirds of the fragment extruding beyond the root apex. The case difficulty and management options, according to Madarati et al.,[9] were discussed with the patient, including:

1) Cleaning/shaping and obturating the root canals to the fragment level.
2) Non-surgical attempt at removing the fragment.
3) Intentional Replantation (surgical approach).

Bypassing the fragment was neglected due to the complexity of the case and the greater possibility of complete extrusion of the fragment into the periapical area. Following a discussion of the above-mentioned management options, the non-surgical removal attempt was agreed on.

After achieving anaesthesia, tight rubber dam isolation was obtained. The preoperative radiographs were analysed, and it was suggested that the portion of the distal canal coronal to the fragment needs to be slightly enlarged to visualise the fragment. This was performed using gates glidden (GG) drills number 2 and 3 under high magnification of the Zumax OMS2350 operative microscope (Zumax Medical Co, Ltd, Jiangsu, China). However, the fragment, unfortunately, remained unseen because it was located under the dentine bridge, where the two C-shaped canals of the Vertucci Type II [2-1][1] root canals' configuration met. Accordingly, a straight-line access was created by preparing the mesial walls of the distal canal, which was coronal to the fragment, using Pesso Reamers #3, 4 (Mani Inc., Tochigi, Japan). Consequently, the coronal aspect of the fragment was seen. The extent of engagement of the fragment with the canal's walls was inspected using an angled endodontic micro explorer (MEDESY, Maniago, Italy), which revealed a firm fragment (no mobility). Accordingly, an attempt to reduce this tight engagement was initiated by inserting K-files (Mani Inc., Japan) #10, 15 till #20, and it proved to be successful. Then an H-file (25/.02) was used in in-and-out movements and a radiograph was taken to confirm the complete bypassing of the fragment (Figure 2-B). Consequently, the fragment became slightly loose, hence the ET25 ultrasonic instrument (Satelec/Acteon, Mérignac, France) was activated carefully around the fragment in a counter-clockwise direction to loosen it more and then remove it coronally out of the canal. Although the fragment became completely free and was moved more coronally (Figure 2-C), it did not come out of the canal. As the fragment was free, any further attempt with ultrasonic vibration could have pushed it more apically. Therefore, the crab-claw shaped tweezers from Zumax broken instrument removal kit (Zumax Medical Co., Ltd., Jiangsu, China) was used to remove it completely (Figure 2-D) (Figure 3-A/B).

A radiograph was taken to confirm the successful and complete fragment's removal (Figure 2-E). The canal's patency was confirmed, the working length was measured, and cleaning and shaping were completed using the Fanta AF−F one (25/.06) rotary file (Fanta Dental, Changzhou, China). Following a calcium hydroxide dressing for one-week, passive ultrasonic irrigation was performed for maximum removal of residual materials. The continuous wave of condensation technique, using the EQ-V Endodontic Obturation System, was applied to fill the root canal system with gutta-percha and ADSEAL resin-based sealer (META-BIOMED Co, Ltd, Cheongju-si, South Korea (Figure 2-F/G). The patient was referred to her general dentist to complete the restorative treatment procedures. After one year, the patient returned for observation and the periapical radiograph showed good signs of healing (Figure 2-H).

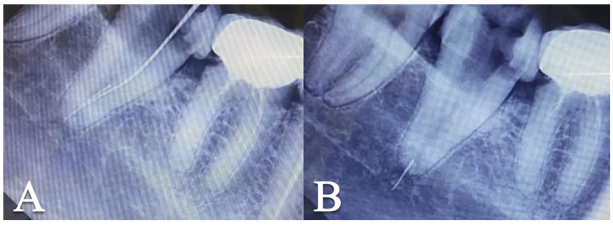

Figure 1: Preoperative radiographs provided by the referring dentists: 1-A Bypassing attempt showing the initial location of the fragment. 1-B Extrusion of the fragment partially beyond the apex following bypassing attempt fragment.

Discussion

Root canal treatments of teeth with C-shaped configurations are challenging because of the anatomical abnormalities in the pulp chamber as well as in the root canal morphology. The prevalence rates of the C-shaped canal system in the second mandibular molars vary among populations, with 9.1% for the KSA population[14] and 2% for the non-Asian population.[1] Also, the instrumental fracture is a common complication when dealing with such complex root canals systems.[15] This can be managed either surgically or conservatively. The latter includes attempts at removing the fragment, bypassing it, or leaving the fragment *in-situ* and continuing treatment with follow-up examinations.[5] Several factors influence the decision regarding the attempt to remove separated instruments.[5] Four factors are listed below:

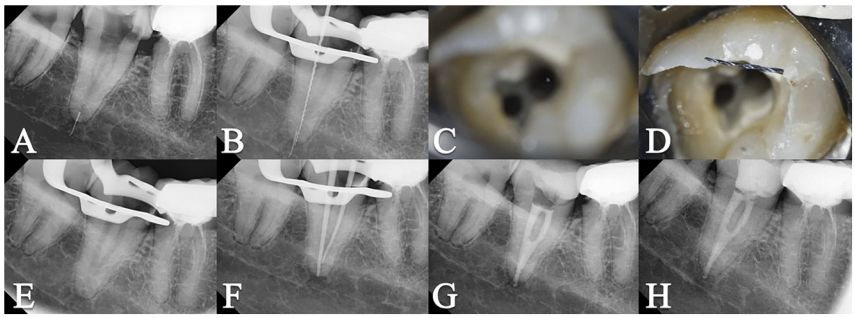

Figure 2: 2-A A diagnostic image. 2-B Bypassing the fragment. 2-C The fragment was located at a higher level. 2-D/E Completely removed. 2-F Cones fitting. 2-G Obturation. 2-H One-year follow-up.

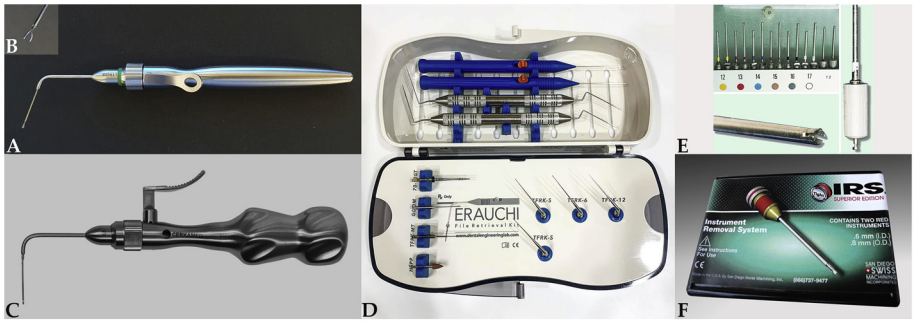

Figure 3: 3-A Microscopic tweezers from Zumax Broken Instrument Removal Kit. 3-B The tip of the crab-claw shaped tweezers. 3-C Endo Removal System. 3-D Terauchi File Retrieval kit. 3-E Masserann Kit. 3-F Instruments Removal System (IRS).

I- Tooth-related factors: anterior or posterior teeth and location of the fragment within the root canal, and its location in relation to the canal's curvatures.
II- Operators' factors: knowledge, a logical sequential approach, and experience.
III- Patients' factors: limited mouth opening, time constraints, anxiety, and unaffordable cost.
IV- Techniques, methods, and instruments used.

Anatomical factors have been considered extremely important, and they could influence the success rate. The more coronal fragments within the root canals, the greater is the success rates of the removal. More importantly, the localisation of fragments in root canal curvatures is crucial. A previous report showed a greater success rate of instruments located before the curvature compared to those located at or beyond the curvature.[3] Moreover, the success rate was the lowest (50%) when fragments were extruded beyond the root apex.[3] Such figures necessitate improvement in techniques, methods, and devices that will enable more predictable and safer removal of fragments located in the apical third of root canals, especially those extruded beyond the apex. Several techniques, methods and devices have been used and suggested for the removal of fractured files.[16–21] The ultrasonics has been reported to be an effective technique, especially when it is performed under the dental operative microscopic magnification that enhances the safe retrieval procedure.[22] The ultrasonic tip is placed in the space between the fragment and the root canal walls, and then, it is activated in a counter-clockwise direction to unscrew the fragment and make it loose coronally before it is completely removed. This should be carefully performed to prevent further mishaps and damages, which may complicate the treatment. Some undesired complications are temperature rise on the external root surface[23] that can damage the periodontal tissues, aggressive dentine removal that increases the risk of roots perforations,[24] and post-operative vertical root fractures,[25] which could be a secondary fracture of the ultrasonic tips or the fractured fragment itself.[20] In addition, pushing the fragment more apically within the root canal or even its extrusion beyond the apex into the periapical tissues may also be encountered, especially if the ultrasonic tips are activated against the top aspect (most coronal) of the fragment. Therefore, complete and safe removal of separated instruments is a difficult and delicate procedure that requires knowledge, clinical hand skills, and sequential and logical clinical judgment, which should be based on each case and the progress of the procedures for each case.[5] Unfortunately, there is a lack of information on how to remove fragments that are located within the apical third and extruded beyond the apex. This gives credit to the current case report that described the procedures in full detail. In the current case, the fragment had already been extruded apically after the bypassing attempt by the referring dentist, who probably did not have enough experience in dealing with such cases or complete awareness of factors and complications about the management options. However, the referring dentist did well by referring the case to a specialist after the first mishap to prevent further complications.

Terauchi[26] reported that when the separated instrument extruded apically, the first ultrasonic attempt may result in pushing the fragment further apically and sometimes out of the canal. He described the loop technique for removing a long-separated instrument from the apical third of the mesial root of a mandibular first molar, that extended about 2 mm beyond the apical foramen.[26,27] The fragment was visible and could be grasped by special removal kits. By contrast, in the current case, the fragment was invisible, about two-thirds beyond the apex, and the tooth itself had complicated anatomy. Therefore, extreme caution was required. Traditional management must be modified when the decision of instrument removal is taken to avoid further complications, which later necessitate surgical intervention, especially if a periapical lesion is present.[11,28] The technique used in this case was divided into four steps, which included re-modified straight-line access, bypassing the fragment, ultrasonic activation of the fragment, and finally, removing it using a special removal kit (crab-claw tweezers from Zumax broken instrument removal kit).

To obtain straight-line access, the first step was re-modifying the root canal space coronal to the fragment, which in turn improved visualisation of the fractured file that was located deeply within the root canal apical third. Though the first enlargement of the canal was not useful, a second careful preparation against the mesial walls of the distal root canal was crucially helpful in visualisation of the coronal aspect of the fragment. Thorough examination of the preoperative radiograph as well as clinical experience were vital in this regard. The second step was to extricate the fragment and withdraw it as coronal as possible before applying the ultrasonic activation. The attempt started using hand files sizes #10, 15, 20, and 25, progressively. Then, H-File #30 was used with in-and-out movements until the fragment became loose. Again, the good experience of the operator was important in preventing extrusion of the fragment beyond the apex, as this mishap is a common complication in such cases. This was one of the main reasons for not attempting to bypass such a fragment at the first instance, as mentioned earlier. The complete extrusion of the fragment beyond the apex in such anatomical area (close to mandibular canal, inferior alveolar nerve) may necessitate complex surgical management if the tooth is to be saved. When the fragment was dislodged using hand files, the third step was ultrasonic vibration. The ultrasonics was applied alongside the fragment to make it completely loose, but it did not come out. With such a scenario, using special removal devices is essential. There are many devices in the market, including Endo Removal System (Cerkamed, Stalowa Wola, Poland) (Figure 3-C), the Terauchi File Retrieval kit (TFRK, Dental Care, California, USA) (Figure 3-D), the Masserann Kit (Micro-Mega, Besançon, France) (Figure 3-E), the Instruments Removal System (IRS) (Swiss Machining Inc, San Diego, USA) (Figure 3-F) and the Zumax Broken Instrument Removal kit (Zumax Medical Co.,Ltd., Suzhaou, Jiangsu, China). As the final step, the crab-claw shaped tweezers from the Zumax Removal kit was used to hold the fragment and take it out.

One may argue regarding the alternative approach if the fragment was not removed. In the current case, because the fragment was bypassed successfully, the alternative approach to complete the fragment removal would have been cleaning, shaping, and filling the root canal system to the full working length. The authors believe that this case's outcome would be more predictable when compared to those cases in which cleaning, shaping, and obturation procedures are terminated at the coronal level of the fragments. However, an agreement with the patient was made on tooth intentional replantation as the last resort before extraction, if periapical lesion developed. Such a surgical intervention may have a success rate up to 95%.[11]

Successful management of separated instruments extruded beyond the apex is a complex process that includes delicate procedures and depends on knowledge of the root canal anatomy, good experience, and availability of the proper armamentarium to cover any possible complications. In addition, the magnification and illumination provided by the operating dental microscope are crucial, not only to improve visibility but also to safely, selectively, and conservatively remove the root canal dentine. Nevertheless, the management of such cases is a challenging process, and the choice of the best technique depends on the specificity of the case and how difficult the case is.

Conclusion

The fractured instrument extruded beyond the apex was successfully and safely managed by implementing different procedures and techniques, including re-modifying the straight-line access, bypassing the fragment, using ultrasonics to loosen it and finally, and removing it by the crab-claw shaped tweezers (Zumax broken instrument removal kit). This case demonstrated the importance of high magnification provided by the dental operating microscope and good clinical skills and judgment; especially to assess the difficulty level of a case, which necessitates implementing different treatment options and approaches. In addition, the availability of proper armamentaria in managing separated instruments is paramount.

Source of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

There are no Ethical or Financial issues, Conflicts of interests, or animal experiments related to this research. The authors certify that they obtained all appropriate patients consent forms. In the form, the patients has given her consent for images and other clinical information to be reported in the journal. The patients understands that her name and initials will not be made to conceal patient identity, but anonymity cannot be guaranteed.

Authors contributions

RK performed the clinical procedures of this case related to the management of the over-extruded separated instrument and wrote the draft for the case report and introduction sections. AAM wrote the discussion, finalised the case report, and critically reviewed the final draft of the manuscript. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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How to cite this article: Kaddoura RH, Madarati AA. Management of an over-extruded fragment in a C-shaped root canal configuration: A case report and literature review. J Taibah Univ Med Sc 2020;15(5):431–436.