

Analysis of Multi-Factors Affecting the Removal of Separated Instruments in Root Canal

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Abstract

Root canal treatment is an important therapy for endodontic diseases. The efficiency and success rate of root canal treatment are on the rise with the development of multidisciplinary joint development, but there are still complications in the process of the treatment. Instruments separation is one of the most serious complications in the root canal treatment. As it occurs, it will seriously affect the efficacy and success rate of root canal treatment, which is a difficult problem for both patients and doctors. This article classifies instrument separation events while analyzes the reason of instrument separation and the factors affecting the occurrence of different types of instrument separation and the characteristics of each type of instrument separation from different perspectives. Through this article, clinicians can avoid the occurrence of instrument separation by analyzing the instrument separation events, and also have a proper analysis of the events that has occurred.

Keywords

Root Canal Preparation, Instrument Separation, Removal of Separated Instruments.

1. Introduction

Root canal treatment (RCT) is the most effective and commonly used method for treating dental pulp disease and periapical diseases. To control the infection and prevent the occurrence of periapical disease and promote the healing of periapical disease, root canal treatment remains three main procedures. First, adopts special equipment and methods to clean and prepare the root canal (root canal preparation), second, apply effective medicine to disinfect the root canal (root canal disinfection), finally, fills the root canal and repair the crown (root canal filling). Due to the complexity of the root canal system and the uncertainty in the treatment process, the success rate of root canal treatment is 80%, not 100% [1].

Root canal preparation is an important part of the serial procedures of root canal treatment. With the development of oral medicine and materials science, the efficiency and success rate of root canal preparation have also grown compared with before. Nevertheless, various complications may also occur during the root canal preparation process in complicated root canal system, such as, steps and deviation and perforation of root canal and instrument separation etc. . Instrument separation is one of the most serious complications, which will directly lead to the failure of root canal treatment. When instrument separation occurs, teeth in inadequate infection control may cause infection and pain to the patient. Studies have shown that the probability of instrument separation is between 0.28% and 16.2% [2]. Parashos et al. [3] conducted the retrospective analysis and investigation on oral general practitioner and endodontics specialists in the study of nickel titanium instruments, they found that 74% of the investigated doctors had instrument separation during root canal treatment, and 72% of the doctors who had instrument separation had broken more than one instrument. Lee et al. [4] investigated the situation of instrument separation in dentists, according to the statistics, 94% of 348 dentists had instrument separation.

There are two main forms of Instrument separation: metal fatigue break and stress concentration break, and the reasons why separation occurs are various, including instrument fatigue, instrument manufacturing process and design, complicated form of root canal system, excessive curvature of root canal, and improper operation of the operator. According to different factors, this paper will analyze and discuss the types of instrument separation from four aspects: the type of separation instruments, the material and length of the separation instruments, the curved degree of the root canal, and the position of the broken instruments.

2. Types of Separated Instruments

The types of instruments used for root canal treatment are complex, according to different treatment progress, broken instruments are different when the instrument separation occurs, such as barbed broach, K file, H file, G drill, spiral conveyor, syringe, etc. Most of the root canal instruments are designed with small diameter and long working length, the working part is covered with different types of screw, and this kind of design also determines that the root canal instruments are easily broken, and the stress concentration point of the instruments is very fragile, the fracture of instruments is easily caused if the use of instruments is improper and violent.

Most of the root canal instruments carry prefabricated screw, and the difficulty will double when removing the fractured pieces, complications such as root canal perforation, uncoiling of the instruments, fractured of the separated instruments, failure of instruments removal will happen. As the most commonly used instruments for pulp extirpation and preparation, H file and K file are frequently used in the clinic, and they are also common in cases of instrument separation. The cross section of K file is made of square or triangular metal wire, and the helix angle is 25° - 40° [1]. During operation, the dentin of root canal can be cut by rotary and lifting movement. When K file occurs to fractured, there is generally some bypass space around the separated instrument, which can provide space for the removal of broken instrument, and the removal rate is high [5]. On the basis of conical metal wire, H file is made by grinding a spiral groove with machine, the cross section is comma shape, the helix angle is 60° - 65° , lifting movement can cut dentin efficiently, but rotary movement cannot be done to avoid break[1]. The shape of the H file determines that when the H file fractured in rotary movement, H file will tightly stuck in the dentin, the bypass space is small, the bypass dredge way is difficult to fulfill, and the pieces is easy to break twice in the process of removing the broken instrument, so the success rate of removing the H file is low. Instruments such as barbed broach and screw conveyor are precisely manufactured and very small, they need to be used correctly to avoid fracture. The barbed broach is made of thin hangnail carved on the metal wire, its diameter is very thin, and the working section is accompanied by hangnail metal wire, it is easy to clip into the small curved root canal dentin entity, or it is broken due to excessive pressure, and it is very easy to break again when the broken instrument is removed.

3. Material and Length of Separated Instruments

Standardized root canal instruments were proposed in 1946, In the 1960s, stainless steel instruments began to put into use in the clinic, nickel and titanium instruments appeared in 1988, with the renewal of material science and oral medical technology, root canal instruments continue to develop and improve in materials, physical properties, and form design, at this stage, the instruments mainly include stainless or carbon steel instruments and nickel and titanium instruments, moreover, metal treatment, metal alloys, coating and innovative technologies have also appeared. Stainless steel instruments have excellent rigidity and high strength, their microhardness is from 522 to 542 vhn [6], and it has been having high occupation ratio in clinical use since its inception. At this stage, most composition of the applied nickel and titanium alloy instruments are 44% titanium (Ti) and 56% nickel (Ni) [7]. Studies have verified that the nickel and titanium alloy instruments have good flexibility and hardness, and they have higher flexibility in the different root canal system treatments in the process of root canal treatment. However, the microhardness of nickel and titanium instruments is 303-362VHN [6], which is easier to break and wear than stainless steel instruments [8]. After the

instrument separation, it is more likely to cause the secondary instrument separation during the removal process. In the retrospective analysis of root canal treatment methods of postgraduates at a dental college in the United States between 2000 and 2004, during the process of root canal treatment of postgraduates, Iqbal et al. [9] found that the separation rates of machine-use nickel and titanium instruments and hand-use various stainless steel production instruments are 1.68% and 0.4%, respectively. In the experiment, Suter B[10] found that the separation rate of nickel and titanium instruments is significantly higher than that of other instruments in curved root canals. M. Hiilsmann [11] found in the research that the length of broken instrument is less than 5mm, and the success rate is 62%, when the length of broken instrument is more than 5mm, the success rate of removing broken instrument increases with the length increase of the broken instrument.

4. Curved Degree of Root Canal

Many domestic and international studies have confirmed that the broken incidence of rotary instruments in curved root canals is significantly higher than that of other instruments. The curved degree of root canal is one of the important factors affecting the removal of separated instruments. The domestic and international studies [10, 12, 13, 14] have shown that with the increase of bending degree of root canal, the success rate of removing separated instruments declines, moreover, the probability of serious complications continues to rise. In the experiment, B. Suter [10] found that during root canal treatment, the separation rate of root canal instruments of curved root canals was significantly higher than that in straight root canals, and the success rate of removing broken instruments in curved root canals was lower than that in straight root canals. Ya Shen [12] pointed out that curved degree is one of the important factors affecting the success of separated instrument treatment, the removal rate of separated instruments of curved root canal declines as the curvature of root canal rises. In the experimental study of the isolated tooth-K file fractured instrument model, Fu Mei [15] found that when the position of separated instrument was certain, the cutting amount of lateral dentin entity at the crown while removing the K file will increase as the curved degree increases, and the difference has statistical significance. This shows that even if the safe straight path is built, the success rate of removing separated instrument will decline with the increase of curvature. The reason is with the increase of root canal curvature, the dentin that needs to be cut laterally around the separated instrument increases. The reduction of the residual amount of tooth tissue will directly lead to the reduction of tooth resistance, moreover, the incidence of perforation of the root canal and other complications will increase.

5. Position of Broken Instruments

The position of instrument separation is uncertain in the process of root canal treatment, which may occur in the upper 1/3 of root canal, the middle 1/3 of root canal and 1/3 of apex. In the previous cases of instrument separation, the removal difficulty was the highest and the success rate was the lowest when the instrument separation occurs at 1/3 of the root canal. Wei Aijun [16] carried out statistical analysis for cases of instrument separation in clinical treatment, compared the removal success rate of the upper 1/3 of root canal with the middle 1/3 of the root canal, the difference did not have statistical significance; compared with the removal success rate of the upper 1/3 of root canal and 1/3 of the apex, the difference had statistical significance. In the experimental study of the isolated tooth-K file broken instrument model, Fu Mei [15] found that when the curved degree of the root canal is certain, the time to remove the separated instrument increases with the increase of the separation depth. In clinical experiment, M. Hiilsmann [9] found without considering the curvature of the root canal, the deeper the position of the separated instrument, the lower the removal success rate of the separated instrument. In the study, Ya Shen [10] found that the success rate of removal the separated instrument at the curved position of the root canal and below the curved degree of root canal was 60% and 31%, respectively, and the difference had statistical significance.

The occurrence of instrument separation will affect the success rate of treatment in two factors: tooth defect and infection control. In the process of root canal treatment, the infection control of the apex

is the key to a successful root canal treatment. The failure of disinfection control caused by instrument separation may lead to residual pulpitis, apical periodontitis, apical cyst, and other complications, which may eventually lead to removal of the affected tooth. According to the discussion of the above-mentioned instrument separation types in this paper, doctors should strictly follow the operating steps in the clinical treatment process, evaluate the condition of the affected tooth properly, make corresponding plans, select proper root canal instruments at different treatment stages, replace the fatigue instruments in time, operate carefully to reduce the occurrence of instrument separation from the source. After the fractured of instrument, the separated instruments and the affected tooth should be evaluated, and the appropriate treatment plan should be selected, it is best to remove the separated instrument and finish the complete root canal treatment. The existing methods of removing the broken instrument include: H file removal method, micro-canula method, micro-ultrasound method, apical surgery and so on. Different removal methods have different indications and characteristics, which should be analyzed and select appropriate before the treatments.

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