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Endodontic treatment and retreatment: a large systematic review

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Abstract

Introduction: In the context of treatment endodontics, endodontic surgery encompasses various procedures for the treatment of teeth with a history of endodontic treatment failures, such as apical surgery, crown and root resections, surgical repair of perforations, and intentional replantation. Endodontic microsurgery is the evolution of traditional apicectomy techniques and incorporates high magnification, ultrasonic preparation of the root end, and filling of the root end with biocompatible materials. **Objective:** It was to carry out a vast literature review in a systematic way to show the main considerations of endodontic treatment and retreatment. **Methods:** The systematic review rules of the PRISMA Platform were followed. The research was carried out from September to November 2022 in Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 120 articles were found, and 75 articles were evaluated and 35 were included in this systematic review. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 20 studies with a high risk of bias and 13 studies that did not meet GRADE. Most studies showed homogeneity in their results, with I2 =96.2% >50%. Modern endodontic surgery uses the dental operating microscope and cone beam computed tomography for preoperative diagnosis and treatment planning. In the presence of persistent endodontic lesions or endodontic failure, endodontic treatment or endodontic surgery is required. In the long term, the risk of failure is identical for both groups, with only a slightly higher risk of failure for non-surgical endodontic retreatments when only two years of follow-up are considered.

Keywords: Endodontic treatments. Endodontic Retreatments. Clinical Research.

Introduction

In the context of treatment endodontics, endodontic surgery encompasses various procedures for the treatment of teeth with a history of endodontic treatment failures, such as apical surgery, crown and root resections, surgical repair of perforations, and intentional replantation. Endodontic microsurgery is the evolution of traditional apicectomy techniques and incorporates high magnification, ultrasonic preparation of the root end, and filling of the root end with biocompatible materials [1]. Modern endodontic surgery uses the dental operating microscope, incorporates cone beam computed tomography for preoperative diagnosis and treatment planning, and has adopted piezoelectric approaches to osteotomy and root manipulation [2].

In the presence of persistent endodontic lesions or endodontic failure, the alternative for the recovery of the dental element is endodontic retreatment or endodontic surgery, which consists of surgical removal of the root apices with retrograde closure of the endodontic [3].

Endodontic retraction is a procedure performed on a tooth that has received a previous attempt at a definitive treatment that has resulted in a condition that requires further additional endodontic treatment to obtain a successful result [1,2]. The major cause of treatment failure is insufficient cleaning and inadequate filling, according to Abou-Rass, 1982 [3]. The

endodontic failure is due to the lack of a technical-scientific-biological basis. Many general practitioners venture into the field, and the failure rate in this group is quite high, around 98.0%, according to Leonardo, 2005 [19].

A condition for successful endodontic retreatment is the proper cleaning of the root canals, therefore, special attention should be given to the technique used to remove the obturator material [14], with the most used cement, pastes, and gutta-percha cones [13,14]. In retreatment, we have to reach the real working length, and completely remove the filling material, clean the root canal and the final filling. Several techniques are described in endodontic retreatment to remove guttapercha, including rotating instruments, manuals, solvents, and their associations [14].

Therefore, the present study carried out a vast literature review in a systematic way to show the main considerations of endodontic treatment and retreatment.

Methods

Study Design

The present study followed a concise systematic review model, following the systematic review rules - PRISMA (Transparent reporting of systematic review and meta-analysis: www.prisma-statement.org).

Search Strategy and Search Sources

The literary search process was carried out from September to October 2022 and was developed based on Scopus, PubMed, Science Direct, Scielo, and Google Scholar, addressing scientific articles from various eras to the present day. The descriptors (MeSH Terms) were used: *Endodontic treatments. Endodontic Retreatments. Clinical Research*, and using the Boolean "and" between MeSH terms and "or" between historical findings.

Study Quality and Risk of Bias

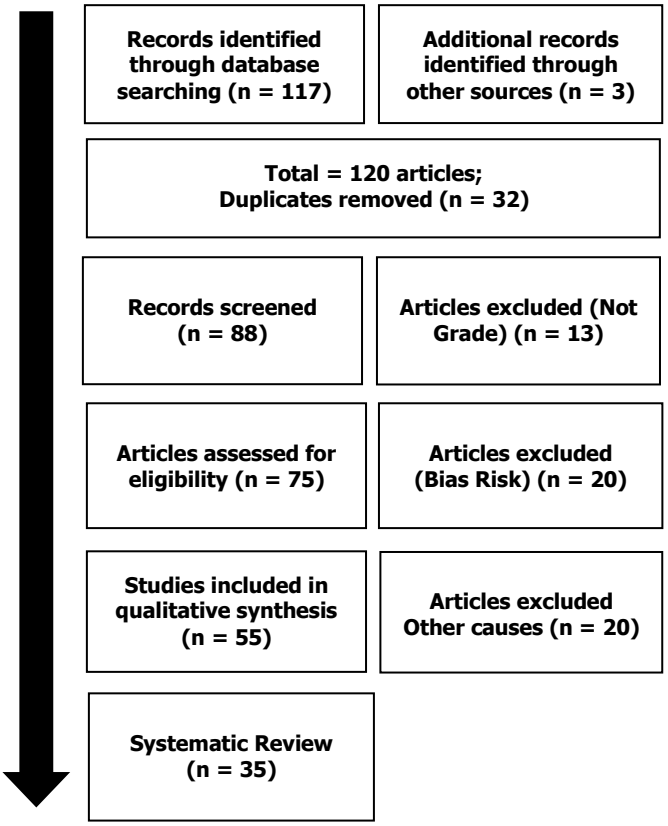
Quality was rated as high, moderate, low, or very low for risk of bias, clarity of comparisons, accuracy, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analysis of randomized clinical trials, followed by randomized clinical trials. The low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument through the analysis of the Funnel Plot graph (Sample size versus Effect size), using Cohen's test (d).

Results and Discussion

Summary of Findings

As a corollary of the literary search system, a total of 120 articles were found that were submitted to the eligibility analysis, and, then, 35 of the 75 final studies were selected to compose the results of this systematic review. The listed studies showed medium to high quality (**Figure 1**), considering in the first instance the level of scientific evidence of studies in types of study such as meta-analysis, consensus, randomized clinical trial, prospective and observational. The biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies showed homogeneity in their results, with I2=96.2%>50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 20 studies with a high risk of bias and 13 studies that did not meet GRADE.

Figure 1. Flow Chart of Study Eligibility (Systematic Review).

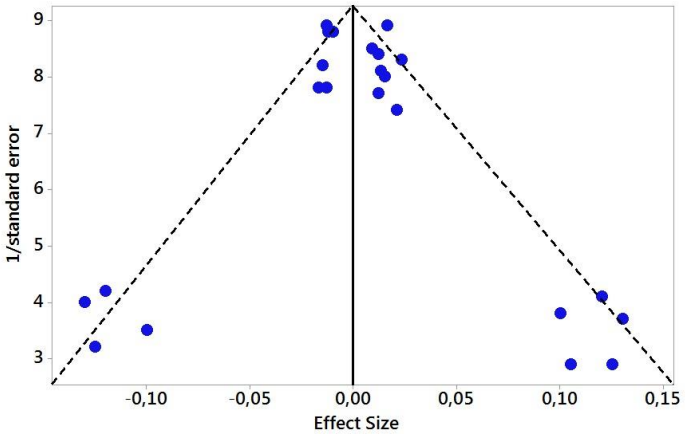


Source: Own authorship

Figure 2 presents the results of the risk of bias in the studies using the Funnel Plot, through the calculation of the Effect Size (Cohen's Test). The sample size was determined indirectly by the inverse of the standard error. The number of clinical studies evaluated was n=35. The graph showed symmetric behavior, not suggesting a significant risk of bias in studies with small sample sizes, which are shown at the bottom of the

graph.

Figure 2. The symmetric funnel plot does not suggest a risk of bias between the small sample size studies that are shown at the bottom of the graph (N=35 studies).



Source: Own authorship.

Results and discussion

A systematic review and meta-analysis study provided an updated Risk Ratio value between the two types of treatment to offer clinicians who propose non-surgical endodontic retreatment or endodontic surgery a direct comparison. Data results from meta-analyses report an aggregate risk ratio (RR) between nonsurgical endodontic retreatment and surgical endodontic retreatment of: 1.05 [0.74, 1.47] at one-year follow-up; RR 2.22 [1.45, 3.41] at two years of followup; an RR 1.08 [0.73 1.62] for a follow-up period of 3-4 years; and an RR 0.92 [0.53, 1.61] for a follow-up period of 8 to 10 years. The results of the present meta-analysis showed that, in the long term, the risk of failure is identical for both groups, with only a slightly higher risk of failure for non-surgical endodontic retreatments, when only two years of follow-up are considered [3].

Bramante and Betti, 2000 [6], evaluated the Quantec system for the removal of guttapercha. In the experiment, the authors used 30 instrumented and filled central incisors, divided into 3 random groups of 10 each. The removal of gutta-percha was performed with the Quantec rotary system and 16: 1 contra-angle reduction and electric motor, varying the speed in each group: group 1 with 350 rpm, group 2, 700 rpm, and group 3 - 1500 rpm, evaluating the time necessary to reach the working duration, the time of removal of gutta-percha, the total time, the apical extrusion of the material during the removal and the number of fractures of the instruments. After removing the material, the teeth were radiographed and the root canal wall was cleaned.

Then, the teeth were striated longitudinally, sectioned, and the cleaning of the root canal walls visually evaluated, scanned with a scanner, and with the measured residues. They observed that the 1500 rpm group was significantly faster than the other groups and that the amount of apically extruded material was not significantly different between groups. When cleaning the middle third, it is possible to notice a radiographically large difference between the 14 groups; in this, the group with 350 rpm presented the largest amount of debris. Group 1 resulted in 6 fractured instruments; In group 2; Four fractured instruments and in group 3 only one fractured instrument. They concluded that the cleanliness and the presence of debris were equivalents between the groups, but the use of 1500 rpm provided greater agility with fewer fractured instruments.

In 2001, Ferreira et al. [7] tested the efficiency of removing gutta-percha using the ProFile system. They selected 48 human teeth with root canals with curvature between 25 and 45, instrumented by the standardized method with Do = 30 and taper 0.04 and filled with vertical gutta-percha condensation. They compared the removal of the filling material between the techniques with flexible K files with chloroform; Type H file with chloroform; ProFile .04 with chloroform and ProFile .04. They measured the technique's execution time and the presence of remaining debris. The roots were divided into apical, middle, and cervical thirds and measured on a scale from 0 (without debris) to 3 (> 50.0% walls with debris) and observed radiographically.

The results of the presence of remaining debris in the root canals instrumented with K + lime chloroform; ProFile + chloroform was lower and did not differ significantly between the three levels of roots examined; While Hedeström and ProFile + chloroform did not show significantly different results in the apical portion. In general, cervical cleaning was superior when compared to the apical third. The results indicated that the ProFile system and the manual files + chloroform have similar cleaning, but that with the ProFile there were 15 greater time savings in the execution of the uncleaning when compared to the manual files.

In the same year, 2001, Betti and Bramante [6] compared the Quantec rotary system with manual instruments for removing gutta-percha. In this, they used 20 upper central incisors of the human being with a single and straight canal, enlarged and filled, which were randomly divided into 2 groups of 10 elements each. In group 1 they used the Quantec SC system and in group 2 the manual files associated with the solvent. They evaluated the following factors: time to reach the working length, time to remove gutta-percha, total time spent, apical extrusion of material during removal, and some fractured instruments.

Furthermore, after the radiographs, the teeth were

striated, cut longitudinally and the cleaning of the root canal was evaluated visually and the respective radiographs were digitalized and the residual residues were evaluated. They checked the cervical, middle, and apical thirds and also for the root canal as a whole. They found that removal time was significantly shorter when using Quantec with SC files, while apically extruded material was not significantly different between groups. Visual and radiographic evaluations of the root canal walls revealed that the hand instruments associated with the solvents performed better than the mechanical system in the cervical third and the root canal as a whole and that, although the Quantec system with SC files takes less time to removal From the filling material, manual files with the concomitant use of solvent clean the root canal more efficiently.

Besides, Schirrmeister et al [9] evaluated the efficacy of removing gutta-percha in curved channels in retreatments using the manual technique, FlexMaster, Protaper and Race observed that the manual and FlexMaster techniques denote larger areas of filling remains and that the Race system presented better results than Protaper due to its cleaning capacity, although slower and with less risk of fractures. Tasdemir et al [11] evaluated the efficiency of three different rotating instruments in removing filling material and concluded that the Protaper system had the lowest averages of material remaining in the root canal walls. However, the instruments used were F1, F2, and F3 and not those intended for retreatment.

Also, Gu et al [10], when studying the Protaper Universal-Retraction system, concluded that all tested techniques left between 10.0% and 17.0% of the surface of the channels covered by the filling material. In the middle and apical thirds, samples from the Protaper group for retreatment showed the lowest percentage of the remnant.

The benefits of using a "single-use" file system for alternative movements are less working time; Less learning curve; Reduction in the number of instruments needed for root canalization; Simplicity (reduction of the number of steps to prepare the canal) and safety about fractures and errors of the instrument during the procedure [12]. Such "unique" instruments are manufactured from a new metal alloy called M-Wire®, which provides greater flexibility and resistance to cyclic fatigue than traditional nickel-titanium alloys. The alternating movement relieves stress on the instrument and consequently reduces the risk of fracturing the instrument caused by cyclic fatigue, caused by the tension and compression of the instrument against the canal walls [12]. According to the author, it is an extremely simple technique. Only direct access to the channel system is necessary without the use of Gates Glidden drills or any other preparation of the channel entry hole. De Deus et al. [13] demonstrated that the movement used to activate the instrument is one of the most important factors in determining resistance to cyclic fatigue. In their study, ProTaper® F2 instruments were used, which were divided into two groups, A and B, group A in reciprocal kinematics, and group B in continuous rotation.

The instruments showed superior resistance to cyclic fatigue when operated in a reciprocal movement when compared to the same instruments operated in continuous rotation. Also, the same authors above performed a quantitative assessment of the dental tissue extruded by the apical foramen during instrumentation of the canal system. The work was carried out on extracted teeth.

For the control group, they used manually instrumented teeth with Flexofile® files, which were pre-extended with Gates Glidden drills. The study was carried out comparing the conventional instrumentation of the ProTaper® system (rotary) and the instrumentation with a single ProTaper® F2 file in reciprocal movement. It was concluded that there is no significant difference in the amount of extruded dental tissue between the two methods of instrumentation Plotinus et al. [23] submitted the two types of instruments, which were divided into four groups of 12, to the different instrumentation programs (Reciproc All and WaveOne All) of the Silver.Reciproc® mechanism, thus confirming that the Reciproc® R25 instrument has a greater cut capacity. efficiency than WaveOne Primary instruments and even greater efficiency when activated in their respective instrumentation program (Reciproc All). Garcia Jr. et al. (2008) [12] compared in vitro the efficiency of removing gutta-percha from root canals using different rotary instruments: ProFile, ProTaper, GT, K3, and Hero. The ProFile, ProTaper, and GT systems achieved the best results, with no statistical difference between them.

Also, Georgi and Sabbagh [22] evaluated the effectiveness of the manual files Hedströen, ProTaper, and R-Endo in removing gutta-percha from severely curved root canals. They noted that all instruments left material within the root canal and that the ProTaper and R-Endo systems are not suitable for the complete removal of the sealing material. On the other hand, other studies have demonstrated the effectiveness of rotational systems in endodontic retreatment but never producing root canals completely free of the obturator.

Further, Plotinus et al. [23] examined the resistance to cyclic fatigue of the Reciproc and WaveOne instruments through simulated root canals. Two groups of fifteen NiTi instruments with an identical size of 25.0 mm were organized, with group A consisting of Reciproc

R25 and group B of WaveOne Primary. All instruments were inspected and the defective one has discarded. Cyclic fatigue tests were performed on an artificial stainless steel channel, reproducing the size and taper of the instruments. The simulated root canal had an angle of 60º of curvature and 5mm of a radius of curvature. The center of the curvature was 5.0 mm from the tip of the instrument and the curved segment of the channel was approximately 5.0 mm long. The Reciproc and WaveOne instruments were activated using each of their pre-specific programs (Reciproc ALL and WaveOne ALL). All instruments were rotated until the occurrence of fracture, time of fracture, and length of the fractured tip, recorded and recorded.

Besides, in the same work, the fracture time was recorded visually using a stopwatch and associated with the nearest whole number. The average length of the fractured fragment was assessed for the correct positioning of the tested instrument within the curvature of the channel, with the presence of similar induced stresses. A longer fracture time is caused by greater resistance to cyclic fatigue. As a consequence, there was a statistically significant difference between the instruments. The Reciproc R25 was associated with a significant increase in the average fracture time when compared to the WaveOne Primary instruments. As a result, Reciproc instruments have been associated with significantly greater cyclic resistance to fatigue than WaveOne instruments [23]. Also, it is known that cyclic fatigue is influenced by the dimensions of the instruments, the alloy, and/or the manufacturing process, which were similar in this study.

Thus, a possible difference between the two instruments tested may be in relation to the oscillatory and rotational movement, which is not clearly revealed by the manufacturers. According to the manufacturer, Reciproc instruments are used in ten cycles of reciprocity per second, equivalent to about 300 rpm, while no information is available for WaveOne instruments. Another possible explanation for the different results obtained in the present study may be related to the different cross-sectional designs of the instruments tested. Therefore, the single use of Reciproc and WaveOne reduces but does not eliminate the risk of fatigue accumulation and metal failure.

Imura et al. [1] conducted a study to assess the effectiveness of the Channel Finder and manual instrumentation in removing gutta-percha during retreatment of the channel. Sixty teeth were used and divided into three groups. In group I, the teeth was manually re-instrumented with type K files number 15 to 50 (two sizes larger than the preparation of the canals). In Group II, the re-instrumentation was performed with the Channel Finder with files from 15 to 50 in diameter. In Group III - the channel was instrumented with type K files, with the modified reduction technique in conjunction with the Channel Finder system. Chloroform was used as the solvent and 0.5% sodium hypochlorite as the irrigation solution.

As a control of the re-instrumentation, an x-ray of each tooth has been performed. If the radiography showed any evidence of clogged material, the tooth has cleaned again until the radiographic examination did not reveal radiopaque material in the canal [30,31]. The following have evaluated: time for retreatment; Extrusion of sealing material apically; Cleaning the canal walls. The teeth were divided longitudinally and photographed. The total areas of the root canal and the debris area were traced and analyzed with a computerized image analysis system [1]. The relationship between the remaining filling material and the root surface was obtained and statistical analysis was performed. The results showed that all the techniques employed left residues inside the root canal. The comparative test showed that the manual technique was significantly better than the others in removing the filling material. All techniques caused extrusion of the buffer material without statistical significance. The hybrid technique required less time to remove the sealing material. The Channel Finder alone was not superior to manual instrumentation [1].

Yared [17] introduced a new concept of preparing channels with only one NiTi instrument driven by a motor, without the prior use of manual instrumentation. The new Reciproc® alternative single file system includes three instruments (R25, R40, and R50), an electric motor (VDW Silver Reciproc), absorbent paper tips, and gutta-percha cones. Only one Reciproc® instrument is used to prepare the channel, depending on the initial size of the channel.

The instruments are manufactured with NiTi M-Wire alloys, which offer greater flexibility and resistance to cyclic fatigue when compared to the conventional NiTi 26 alloy. It has an "S" shaped cross-section. The three instruments have regressive taper: at R25, the tip diameter is 0.25 mm and the cone 8% up to 3 mm from the tip; In the R40, the tip diameter is 0.40 mm and the taper is 6% up to 3 mm from the tip; on the R50, the tip diameter is 0.50 mm and the cone is 5.0% to 3.0 mm from the tip. The instruments are used in 10 cycles per second of alternating motion, at approximately 300 rpm. The angles of the clockwise and counterclockwise movements are different [17].

The selection of the Reciproc® instrument is based on the preoperative radiographic analysis. When the channel is partially or completely invisible on the radiograph, R25 must be selected. In other cases, when the radiography shows the channel clearly up to the

apex and the channel is considered medium or wide, a file number 30 must be inserted, possibly at the working length. If the channel is considered wide, the R50 must be used, but if the file no. 30 does not enter passively, one must choose a file no. 20 for passive insertion, and then the channel will be considered medium, opting for R40. If file 20 does not enter passively, the channel is considered attractive and one must choose the file R25. In the alternate movement, the clockwise and counterclockwise angles determine the amplitude of the right and left rotation movement. The Reciproc® instrument must be inserted into the channel with small rotation movements without completely removing the instrument from the channel and the amplitude of the movements must not exceed 3.0 to 4.0 mm [17].

A little pressure should be applied. After this insertion, the instrument must be removed to clean the canal and a file number 10 must be used to check the permeability in 2/3 of the CT. Plentiful irrigation must be carried out. Preliminary studies have demonstrated the ability to centralize these instruments, even in severely curved channels. They are considered safe for fractures due to the reciprocating movement to the right and left, which allows the instruments not to reach the fracture angle in the twists and blocks. The working time is four times faster when compared to rotary NiTi preparations. With the use of the system, there is a lower incidence of complications, such as apical deviation, steps, and channel blocking, when compared to traditional rotational techniques, and elimination of cross-contamination among patients, since the instrument is discarded after use [27].

Capar et al. [18] compared the resistance to cyclic fatigue of new endodontic instruments - ProTaper® Next X2 (M wire), OneShape® (conventional NiTi), Revo-S® Shaping Universal, and HyFlex® 25 / 0.6 NiTi with controlled memory) with o Revo-S® instruments. Four groups of 20 NiTi instruments were tested on steel channels with a radius of 3 mm and an angle of curvature of 60 °. HyFlex® files showed greater resistance to fatigue and Revo-S® showed less resistance between groups ($p < 0.001$).

In 2003, Valois and Costa [19] carried out a study to evaluate in vitro the efficiency of the ProFile Taper .04 series 29 system in the treatment of curved root canals. For this, 62 teeth of the lower first molar with mesial roots and curvature between 25 and 30 degrees were selected. The root canals were instrumented from the anatomical diameter to file No. 35 and filled by the lateral condensation technique, using Sealer 26 as a sealer cement. Then, the teeth were randomly distributed into 6 groups with 20 root canals each: GI - conventional technique + solvent; GII - conventional technique + solvent + ultrasound; GIII - ProFile + solvent: GIV - ProFile + solvent + ultrasound; GV - ProFile; 18 GVI - ProFile + Ultrasound. Four samples were used as controls. The following factors were evaluated: time spent, presence of material extruded by the apical foramen, cleaning of the root canal walls, and safety of the instruments used. The data were submitted to ANOVA and Tuckey tests. The authors concluded that the use of ProFile files replaces the need for solvent when retreating curved channels. However, these instruments should be used with caution.

Berutti et al. [25] compared the channel curvature and axis modulation after instrumentation with the WaveOne Primer for the rotary and rotary nickel-titanium rotary, essential to determine the effectiveness of all subsequent chemical disinfection and root canal filling procedures. Using ISO 15 training blocks, 0.02 mm cone, all with slide guides created previously with PathFile 1,2,3 in the working length, two groups were created for modeling [25].

The first, using the ProTaper S1-S2-F1-F2 sequence, and the second, using the WaveOne Instrument ISO 25 and the 0.08 mm taper, both in working length. The pre and post instrumentation digital images were superimposed and processed by a two-dimensional photographic method (2D) to analyze the radius curvature ratio (CRR), which, when closer to the value of 100, caused by the instrumentation, and relative error of the axis (rae), the smaller, the smaller the shape of the channel was modified by instrumentation, representing the modification of the curvature of the channel. The results showed that the instrument factor was extremely significant for the CRR and rae parameters, with reduced channel modification when the unique NiTi WaveOne instrument system is used, in order to preserve the integrity and location of the channel and apical anatomy, Preparation for proper filling. These results can be particularly significant when the dentin thickness is less [25].

Gavini et al. [26] evaluated the flexural fatigue strength of the 25 mm nickel-titanium reciprocal instrument and the 0.08 mm super-elastic NiTi M-Wire cone, which presents greater flexibility (close to 300-800%) and greater strength to Cyclic fatigue than the conventional NiTi wire using continuous rotation and / or oscillatory and rotational movement. Two groups were created according to the applied kinematics of continuous rotation (RC group) and oscillatory and rotational movement, described as reciprocal (group MR). The instruments were subjected to dynamic test devices powered by an electric motor with a speed of 300 rpm, allowing movements of the biceps, with 2.0 mm in each direction, through a tempered metal block simulating the instrumentation of a root canal with 40º curvature and 5mm radius [26].

Also, the electric motor has been standardized to perform continuous rotation at a speed of 300 rpm and the oscillatory and rotational movement, characterized by counterclockwise and clockwise rotation, with a 120º difference between the two, performing ten movement cycles oscillatory and per second, equivalent to 300 rpm. The fracture of the instrument was detected by the device's sensor and the surface examined by scanning electron microscope. The time was recorded in seconds and later converted into the number of fracture cycles. Instruments powered by oscillatory and rotational movements reached a significantly greater number of cycles before fracture (average 1787.78 cycles) when compared to the same types of instruments driven by continuous rotation.

SEM images showed fatigue streaks that characterize the occurrence of fatigue failure and result in spherical dimples representative of a ductile fracture. Micro voids and cracks have also been found [26]. Therefore, the kinematics of the movement of NiTi instruments significantly influenced the cyclic fatigue of the Reciproc R25 instrument, when the number of fracture cycles and the time in seconds were almost double in the RM group compared to the RC group. The oscillatory and rotational movement, proposed by Yared, improves the resistance to flexural fatigue in a nickel-titanium instrument compared to the continuous rotation movement, because the clockwise rotation is superior to the clockwise rotation (disengagement), resulting in a compression of the screw effect, with reduction of the compression forces favorable to the occurrence of elastic deformation and fracture by torsion by locking the tip [26, 27-31].

Conclusion

Modern endodontic surgery uses the dental operating microscope and cone beam computed tomography for preoperative diagnosis and treatment planning. In the presence of persistent endodontic lesions or endodontic failure, endodontic treatment or endodontic surgery is required. In the long term, the risk of failure is identical for both groups, with only a slightly higher risk of failure for non-surgical endodontic retreatments when only two years of follow-up are considered.

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Ethics approval

Not applicable.

Informed consent

Not applicable.

Data sharing statement

No additional data are available.

Conflict of interest

The authors declare no conflict of interest.

Similarity check

It was applied by Ithenticate@.

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