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Major aspects of minimally invasive endodontic surgery using microsurgery: a systematic review

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Abstract

Introduction: Knowledge about endodontic infections has increased significantly over the last 50 years and, although many issues still require elucidation, endodontics has become the dental science that has the most improved approaches and technologies to increase the success and longevity of treatments dental organs. Endodontic microsurgery has produced highly successful results in preserving teeth with persistent or recurrent cases of periapical periodontitis that could not be successfully treated by non-surgical endodontic approaches. **Objective:** It was to list the main clinical considerations of minimally invasive endodontic surgery using apical microsurgery, as well as point out the success rate of this technique. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from January to March 2024 in the 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 117 articles were found, 50 articles were evaluated in full and 20 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 10 studies with a high risk of bias and 21 studies that did not meet GRADE and AMSTAR-2. Most studies did not show homogeneity in their results, with X^2=58.5%<50%. It was concluded that the success of apical endodontic surgery in terms of healing existing periapical pathology, together with a good long-term prognosis, depends on correct diagnosis and planning, as well as the association of surgical techniques, well-executed protocols, and biocompatible materials. The apical endodontic microsurgery approach is predictable and has a high success rate, which resulted from the introduction of cone beam computed tomography, microscope, ultrasonic instruments, and materials such as mineral trioxide aggregate (MTA) and bioceramics for retro-fillings.

Keywords: Endodontic treatment. Apical endodontic microsurgery. Minimally invasive surgery. Diagnosis. Planning.

Introduction

Knowledge about endodontic infections has increased significantly over the last 50 years and, although many issues still require elucidation, endodontics has become the dental science that has the most improved approaches and technologies to increase the success and longevity of dental organs [1]. Endodontic microsurgery has produced highly successful results in preserving teeth with persistent or recurrent cases of periapical periodontitis that could not be successfully treated by non-surgical endodontic approaches [1-3].

Even though initial endodontic therapy has high rates of predictability and success, the persistence of inflammatory disease of the periradicular tissues (periodontitis apical) is attributed to the following factors, such as persistent intraradicular infection in the complex system of apical root canals; extra-articular infection, usually in the periapical form of actinomycosis; extruded root canal filling or other materials exogenous substances that cause a foreign body reaction; accumulation of endogenous crystals of cholesterol that irritates the periapical tissues; true cystic lesions and scarring of the scar tissue from the injury [3,4].

Identifying the origin of failure in endodontic treatment is a sine qua non for achieving successful long-term results and the preferable option for management of this clinical situation is non-surgical endodontic retreatment, with a success rate overall weighted 78%. However, in cases where retreatment non-surgical endodontic treatment is not feasible and/or the likelihood of improved treatment is very low, there is still the possibility of performing retrograde treatment through apical endodontic surgery [5]. However, the combination of high technology in the technical and clinical approach became extremely essential for the success of the treatment [6,7]. Once the techniques were improving and companies developing more technological and biocompatible materials, apical endodontic microsurgery (AEM) became a safer and more predictable procedure, with success rates reaching 93.5%, according to the metaanalysis carried out by Setzer et al (2010) [8].

This new technique recommends the use of microinstruments and inserts ultrasonic devices to perform resection and retro preparation of the root, use of materials more biocompatible obturators, under the detailed observation promoted by microscopes high magnification and high illumination procedures, allowing the surgeon the ability to identify anatomical variations, previous iatrogenesis, isthmuses, lateral and accessory canals [1,2].

Therefore, the present study aimed to list the main clinical considerations of minimally invasive endodontic surgery using microsurgery, as well as point out the success rate of this technique.

Methods

Study Design

The present study followed the international systematic review model, following the rules of PRISMA (preferred reporting items for systematic reviews and meta-analysis). Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed on: 02/14/2024. The methodological quality standards of AMSTAR-2 (Assessing the methodological quality of systematic reviews) were also followed. Available at: https://amstar.ca/. Accessed on: 02/14/2024.

Data Sources and Research Strategy

The literary search process was carried out from January to March 2024 and was developed based on Scopus, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various eras to the present. The descriptors (MeSH Terms) were used: *"Endodontic treatment. Apical endodontic microsurgery. Minimally invasive surgery. Diagnosis. Planning"*, and using the Boolean "and" between the MeSH terms and "or" between historical discoveries.

Study Quality and Risk of Bias

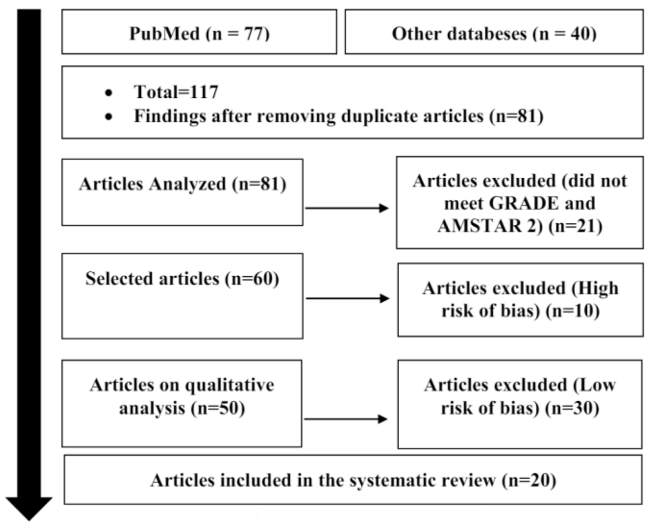
Quality was classified as high, moderate, low, or very low in terms of risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analyses of randomized clinical trials, followed by randomized clinical trials. The 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 by analyzing the Funnel Plot graph (Sample size versus Effect size), using the Cohen test (d).

Results and Discussion

Summary of Findings

A total of 117 articles were found that were subjected to eligibility analysis, with 20 final studies being selected to compose the results of this systematic review. The studies listed were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, 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 X^2=58.5%<50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 10 studies with a high risk of bias and 21 studies that did not meet GRADE and AMSTAR-2.

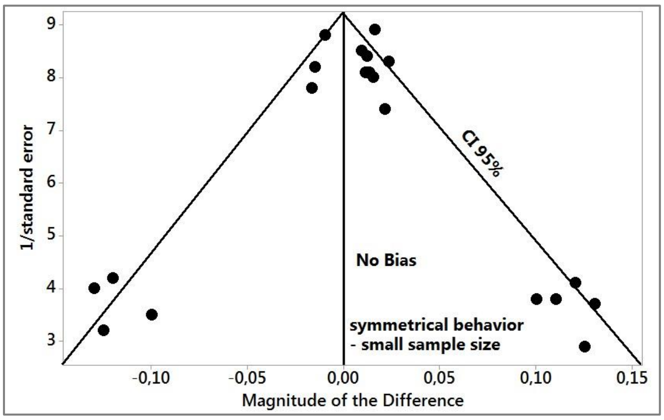
Figure 1. Articles eligibility process.



Source: Own authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using the Cohen Test (d). Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph had a symmetrical behavior, not suggesting a significant risk of bias, both between studies with a small sample size (lower precision) that are shown at the bottom of the graph and in studies with a large sample size that are presented at the top.

Figure 2. The symmetric funnel plot suggests no risk of bias among the small sample size studies that are shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (n=20 studies).



Source: Own authorship.

Major Clinical Outcomes

For a long time, the presence of persistent and recurrent infections in endodontics was considered a factor that would eventually lead to tooth extraction, mainly due to the existence of limitations in traditional apical surgeries, such as lack of knowledge of apical anatomy, the use of materials with low biocompatibility with adjacent tissues, difficulty in visualization, access and execution of the procedure, which resulted in studies reporting low success rates. This was often reinforced by the different specialties of dentistry, which differed in their treatment approach, recommending the placement of implants, and making the incidence of high-evidence studies on long-term results low [1-3].

In recent decades, with the development of new technologies in both equipment and materials, many studies have been carried out to report the results of apical endodontic microsurgery (AEM) and definitively introduce this technique into clinical approaches to save a dental element [4]. In 2009, Torabinejad et al. [9] have already demonstrated in a systematic review, with articles published up to 38 years before this meta-analysis, that the success rates for endodontic surgery and non-surgical endodontic retreatment were very similar (about 7578%). However, despite the minimum follow-up time of 2 years for inclusion in this review, many studies were carried out by students, using teeth with pre-operative predictors of failure, some without carrying out preparations and fillings of the root end or the report of the technique used.

The lack of high-quality, long-term randomized clinical trials was also an important factor to be considered in the systematic review carried out by Setzer et al. (2010) [8]. This meta-analysis, which was carried out to compare the results of traditional endodontic surgeries and apical endodontic microsurgery and presented stricter article selection criteria, had to define a minimum follow-up time of 6 months, to achieve sufficient data for cases using the traditional technique. This would produce a bias in the results, as there are no studies for AEM with a follow-up of less than 12 months.

Carrying out new high-quality studies comparing these techniques would currently be unfeasible, since the implantation of amalgam, containing mercury, in the connective tissue would not be approved by the ethics committee. Thus, studies began to evaluate the success rates of AEM alone and evaluate which factors were contributing to the significant improvement of this index [5,6].

The introduction and evolution of cone beam computed tomography (CBCT) in dentistry was essential for the better quality of scientific studies and indication of AEM. Although few studies compare the healing of apical periodontitis on periapical radiographs versus CBCT, after apical endodontic surgery with a follow-up period ranging from 4 to 12 months postoperatively, the results presented when studies are carried out with the CBCT monitoring are different when done using 2D images. Safi et al. (2019) [10], presented a randomized controlled study that is in line with other previously performed, in which the difference in value between the completely healed category on PA radiography versus CBCT has a discrepancy in the range of 25%. Completely healed teeth on CBCT imaging was 50% compared to 74% on PA radiography. These data often do not indicate a failure in the success of AEM, but rather that the need for more reliable tools for the real clinical situation is necessary for better diagnosis and case planning, as well as for monitoring the success of the treatment.

Another factor that demonstrated a direct relationship with the prognosis of AEM was the high magnification and visualization of the operative field through the microscope, reproducing a better perspective on execution and results. The meta-analysis by Von Arx et al. (2010) [11] found that the use of an endoscope significantly improved outcomes compared to cases where no magnifying devices were used. This result was confirmed by a more recent meta-analysis by Setzer et al. (2012) [12] based on 14 longitudinal studies in which the probability of success for modern endodontic surgery using a microscope or endoscope was significantly higher than endodontic surgery using loupes or without magnifying devices. Thus, the use of adequate magnification during surgical procedures seems important [1].

Furthermore, at the level, 3 mm from the original apex, 90% of the mesiobuccal roots of the upper first molars have an isthmus, 30% of the upper and lower premolars, and more than 80% of the mesial roots of the lower first molars have an [13]. The inability to treat these regions using the traditional technique proved to be one of the main causes of failure in both orthograde and retrograde surgical treatment, reaffirming the efficiency and precision achieved by the microscope and preparations with ultrasonic instrumentation.

The depth and sealing property of the root filling material was also a significant prognostic factor postoperatively. In general, having an inadequate depth resulted in failed RP and CBCT imaging. When the mineral trioxide aggregate (MTA) was at an inadequate depth, there was a significant association with PR failure. Cases with inadequate MTA depth were 18 times more likely to fail CBCT imaging. As the depth of the root end filling correlates with an adequate seal, it can be speculated that for the MTA and Root Repair Material (RRM) seal it should be a minimum depth of 2.5 mm or more [10]. This is only possible through preparation with ultrasound tips.

Despite excellent results obtained with retropreparations with ultrasound tips, some studies reviewed in the meta-analysis by Abella et al. (2014) [14], demonstrate the occurrence of dentin cracks in dry ends after retrograde preparation with ultrasound. However, in these in vitro studies, some factors such as the stress exerted by the extraction, risk, and storage of these roots, and inadequate handling, may produce a bias concerning the results of these studies. When the study is carried out on fresh cadavers, it can be observed that the periodontal ligament acts as a shock absorber, preventing the propagation of cracks caused by these vibrations, and tip ultrasonics do not produce a significant number of microcracks.

Given the technical development of AEM, the importance of biocompatibility and mechanical properties of filling materials. In studies carried out in dogs, by Chen et al (2015) [15], to evaluate healing after apical endodontic surgeries and compare the results of RRM and MTA, showed the formation of cementum-like tissue and periodontal ligament on the surfaces of both materials, suggesting high healing induction and biocompatibility.

Also, *in vitro* studies demonstrate that these materials have physical and similar mechanics, with overall success rates for MTA and RRM cases in two-dimensional radiography of 94.7% and 92%, respectively [1,2]. Despite the positive results presented by RRM, a more elaborate design of prospective clinical studies is still necessary to evaluate this new material, since laboratory models of bacterial infiltration can generate inconsistent results. However, RRM may have better inductive/conductive properties of mineralized tissue, accelerating the deposition of cemental tissue and making healing better and faster than MTA [5,15].

According to Siqueira and Rôças (2011) [16], if bacteria continue to remain in the canal after resection, elimination by retro preparation, and enclosure of bacteria residues caused by the filling material, if necessary. This fact was proven by the meta-analysis carried out by Kohli et al. (2018) [17], in which the sum of the best evidence available showed that the axial cavity preparation promoted by ultrasonic instruments with retro-filling materials such as MTA, significantly increasing the rates of success of AEM when compared with shallow concave preparations and placement of composite resin as the material of choice. This tells us how important it was to the evolution of the traditional apical endodontic surgery technique to microsurgery apical endodontic.

As a limitation, the presence of defects in hard tissues can affect the outcome of endodontic microsurgery. The data presented can assist physicians' decision-making process by examining certain preoperative prognostic variables when considering endodontic microsurgery as a treatment option [1]. Clinical cases with more favorable hard tissue characteristics lead to a better prognosis in endodontic microsurgery. To avoid complications in conditions in which periapical lesions invade anatomical structures, such as the nasopalatine nerve tube and the mandibular canal, selective curettage has been proposed as an alternative option to complete curettage in surgery [18-20].

Conclusion

It was concluded that the success of apical endodontic surgery in terms of healing existing periapical pathology, together with a good long-term prognosis, depends on correct diagnosis and planning, as well as the association of surgical techniques, well-executed protocols, and biocompatible materials. The apical endodontic microsurgical approach is predictable and has a high success rate, which resulted from the introduction of cone beam computed tomography, microscope, ultrasonic instruments, and materials such as MTA and bioceramics for retro-fillings.

CRediT

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Conflict of Interest

The authors declare no conflict of interest.

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References

1. Sabeti M, Ihsan MS, Kharat P, Azarpazhooh A. The effect of hard tissue defects on the clinical outcome of endodontic microsurgery: a systematic review and meta-analysis. Clin Oral Investig. 2023 Dec;27(12):7079-7089. doi: 10.1007/s00784-023-05341-3.
2. Li N, Zhang R, Qiao W, Meng L. Conservative endodontic microsurgery to protect critical anatomical structures-selective curettage: a case series. BMC Oral Health. 2023 Aug 31;23(1):615. doi: 10.1186/s12903-023-03287-2.
3. Lio F, Mampieri G, Mazzetti V, Leggeri A, Arcuri L. Guided endodontic microsurgery in apicoectomy: a review. J Biol Regul Homeost Agents. 2021 May-Jun;35(3 Suppl. 1):47-55. doi: 10.23812/21-3supp1-7.
4. Wang N, Liu H, Shen Y. Endodontic microsurgery for failed regenerative endodontic procedures. Asian J Surg. 2023 Dec;46(12):6093-6094. doi: 10.1016/j.asjsur.2023.09.078.
5. Teh LA. Endodontic Microsurgery on a Persistent Periapical Lesion. Cureus. 2023 Jul 1;15(7):e41250. doi: 10.7759/cureus.41250.
6. Zhang M, Liu H, Shen Y. The bone lid technique in endodontic microsurgery. Asian J Surg. 2023 Sep 7:S1015-9584(23)01414-8. doi: 10.1016/j.asjsur.2023.09.011.
7. Carpegna G, Scotti N, Alovisi M, Comba A, Berutti E, Pasqualini D. Endodontic microsurgery virtual reality simulation and digital workflow process in a teaching environment. Eur J Dent Educ. 2023 Sep 16. doi: 10.1111/eje.12946.
8. Setzer FC. et al. Outcome of endodontic surgery: a meta-analysis of the literature-- part 1: Comparison of traditional root-end surgery and endodontic microsurgery. Journal of endodontics, 2010, v. 36, n. 11, p. 1757–65.
9. Torabinejad M. et al. Outcomes of Nonsurgical Retreatment and Endodontic Surgery: A Systematic Review. Journal of Endodontics, 2009, v. 35, n. 7, p. 930–937.
10. Safi C. et al. Outcome of Endodontic Microsurgery Using Mineral Trioxide Aggregate or Root Repair Material as Root-end Filling Material: A Randomized Controlled Trial with Cone-beam Computed Tomographic Evaluation. Journal of Endodontics, 2019, v. 45, n. 7, p. 831-839.
11. Von Arx T, Peñarrocha M, Jensen S. Prognostic factors in apical surgery with root-end filling: a meta-analysis. Journal of endodontics, 2010, v. 36, n. 6, p. 957-73.
12. Setzer FC. et al. Outcome of endodontic surgery:

a meta-analysis of the literature-- Part 2: Comparison of endodontic microsurgical techniques with and without the use of higher magnification. Journal of endodontics, 2012, v. 38, n. 1, p. 1-10.
13. Kim JE, Shim JS, Shin Y. A new minimally invasive guided endodontic microsurgery by cone beam computed tomography and 3-dimensional printing technology. Restorative Dentistry & Endodontics, 2019, v. 44, n. 3.
14. Abella F. et al. Applications of Piezoelectric Surgery in Endodontic Surgery: A Literature Review. Journal of Endodontics, 2014, v. 40, n. 3, p. 325–332.
15. Chen I. et al. Healing after Root-end Microsurgery by Using Mineral Trioxide Aggregate and a New Calcium Silicate–based Bioceramic Material as Root-end Filling Materials in Dogs. Journal of Endodontics, 2015, v. 41, n. 3, p. 389-399.
16. Siqueira JR JF, Rôças IN. Microbiologia e tratamento das infecções endodônticas Caminhos da Polpa / editores Kenneth M. Hargreaves, Stephen Cohen ; tradução Alcir Costa Fernandes Filho... [et al.]. - Rio de Janeiro : Elsevier, 2011, pag 512-549.
17. Kohli MR. et al. Outcome of Endodontic Surgery: A Meta-analysis of the LiteraturePart 3: Comparison of Endodontic Microsurgical Techniques with 2 Different Root-end Filling Materials. Journal of endodontics, 2018, v. 44, n. 6, p. 923–931.
18. Albagle A, Kohli MR, Kratchman SI, Lee SM, Karabucak B. Periapical healing following endodontic microsurgery with collagen-based bone-filling material: A randomized controlled clinical trial. Int Endod J. 2023 Dec;56(12):1446-1458. doi: 10.1111/iej.13973.
19. Tang Y, Xu K, Chen Y, Lu L. Evaluating the efficacy of endodontic microsurgery for teeth with an undeveloped root apex and periapical periodontitis after nonsurgical treatment failure. BMC Oral Health. 2023 Jun 22;23(1):414. doi: 10.1186/s12903-02303117-5.
20. Liu C, Liu X, Wang X, Liu Y, Bai Y, Bai S, Zhao Y. Endodontic Microsurgery With an Autonomous Robotic System: A Clinical Report. J Endod. 2024 Feb 17:S00992399(24)00098-0. doi: 10.1016/j.joen.2024.02.005.

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