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Clinical significance of parendodontic surgery and microsurgery: a systematic review

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Abstract

Introduction: In the context of parendodontic surgery (or endodontic/apical surgery), root canal therapy has a success rate above 80%, and root canal retreatment has a success rate of 50 to 80%. The introduction of dental operating microscopes has helped increase treatment success rates. **Objective:** The aim was to develop a systematic review of the literature to highlight and describe the main approaches of parendodontic surgery and microsurgery in relation to the success of endodontic treatment. **Methods:** The systematic review rules of the PRISMA Platform were followed. The research was carried out from May to June 2025 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 116 articles were found, and 50 articles were evaluated in full and 43 were included and developed in this systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 23 studies with a high risk of bias and 23 studies that did not meet GRADE and AMSTAR-2. It was concluded that the success rates of parendodontic surgeries depend on the surgical modality indicated, the type of retrofilling materials used, the quality of the root canal filling prior to surgery, the treatment of surgical pockets, the execution of surgical techniques, and the periodontal conditions. The success of the surgery is higher when it is supplemented by root canal retreatment. Parendodontic surgery aims to remove the etiological factor and prevent recontamination of periodontal tissues after the etiological agent has been removed. The main indications for periodontal surgery are anatomical complications, drainage, pain relief, iatrogenic problems, trauma, periodontal problems, the need for biopsy, foreign bodies in the apical region, incomplete or dilated apices, prosthetic procedures after endodontics, and failures or problems during treatment.

Keywords: Parendodontic surgery. Endodontic surgery. Microsurgery. Indications. Types of surgeries.

Introduction

In the context of parendodontic surgery (or endodontic/apical surgery), root canal therapy has a success rate above 80%, and root canal retreatment has a success rate of 50 to 80% [1,2]. The introduction of dental operating microscopes has helped increase treatment success rates. Three main types of endodontic microsurgery are currently performed: apical microsurgery, periradicular microsurgery, and microscopic intentional reimplantation. Apical microsurgery is a surgical procedure on the root apex, including osteotomy, root apex resection, root apex preparation, and obturation under a microscope [3].

For cases where apical microsurgery is not feasible, microscopic intentional reimplantation is indicated. This is the insertion of a tooth into its socket after tooth extraction for the purpose of performing a treatment under a microscope, such as root apex filling or perforation repair. Periradicular microsurgery, including amputation and root hemisection, is a surgical procedure for removing the root or roots of a tooth [3,4].

Compared to traditional apical surgery, apical microsurgery offers advantages such as precise identification of the root apices, small osteotomy, a shallow bell angle in root apex resection, clear exploration of the resected root surface, and precise preparation of the root apex. Apical microsurgery is precise and minimally invasive, with a success rate of over 90% [5].

Endodontic surgery, such as apical/periapical microsurgery, aims to heal periradicular tissues, resulting in the rehabilitation of dental function. It is indicated in cases such as retrofilling and periradicular tissue repair [5-7]. The failure of non-surgical endodontics stems from the fact that, in some cases, the need for root canal treatment arises in response to technical problems combined with microbiological problems [8,9].

In this sense, endodontic surgery is a suitable surgical procedure for the treatment of teeth with periapical lesions that do not respond to conventional endodontic treatment, or when retreatment is not possible. Endodontic surgery is a surgical technique that should be considered as a treatment option for resolving periapical problems. It is an alternative to avoid tooth extractions and is a treatment option when conservative endodontic procedures have failed [1,2,10].

As a corollary to this, endodontic surgery consists of removing the etiological agent, namely the presence of bacteria and other microbial irritants, from the root canals. The most common approach involves sealing all available entry orifices into the root canal system. It is also indicated in cases of persistent chronic periapical inflammation with extensive apical radiolucent areas, restricted coronal access to the root apex due to insufficient retrograde sealing or unremovable root posts, perforation and fracture of the apical third of the root, and pulp calcifications in the root third, among others. The decision to perform endodontic surgery should be based on the evaluation of each case, and is indicated only when all conventional endodontic therapy options have been exhausted [8-10].

The aim was to develop a systematic review of the literature to highlight and describe the main approaches of parendodontic surgery and microsurgery in relation to the success of endodontic treatment.

Methods

Study Design

This study followed the international systematic review model, following the PRISMA (preferred reporting items for systematic reviews and meta-analysis) rules. Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. It was accessed on: 06/10/2025. The AMSTAR-2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. It was accessed on: 06/10/2025.

Data Sources and Search Strategy

The literature search process was carried out from May to June 2025 and developed based on Web of Science, Scopus, Embase, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various periods to the present day. The descriptors (DeCS/MeSH Terms. Available on: https://decs.bvsalud.org/) were used: "Parendodontic surgery. Endodontic surgery. Microsurgery. Indications. Types of surgeries", and using the Boolean "and" between MeSH terms and "or" between historical findings.

Study Quality and Risk of Bias

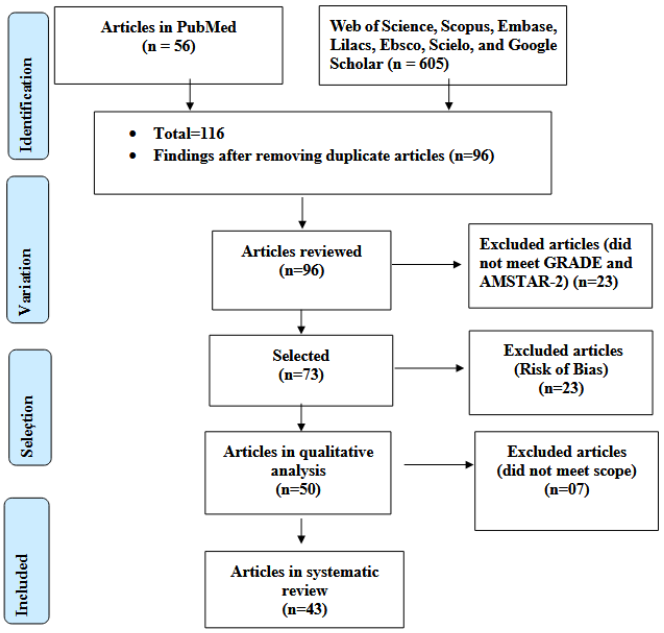
The quality was classified as high, moderate, low, or very low regarding the risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analysis of randomized clinical trials, followed by randomized clinical trials. 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 Cohen's d test.

Results and Discussion

Summary of Findings

A total of 116 articles were found. Initially, duplicate articles were excluded. After this process, the abstracts were evaluated, and a new exclusion was performed, removing the articles that did not include the topic of this article, resulting in 96 articles. A total of 43 articles were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 23 studies with high risk of bias and 23 studies that did not meet GRADE and AMSTAR-2, according to Figure 1.

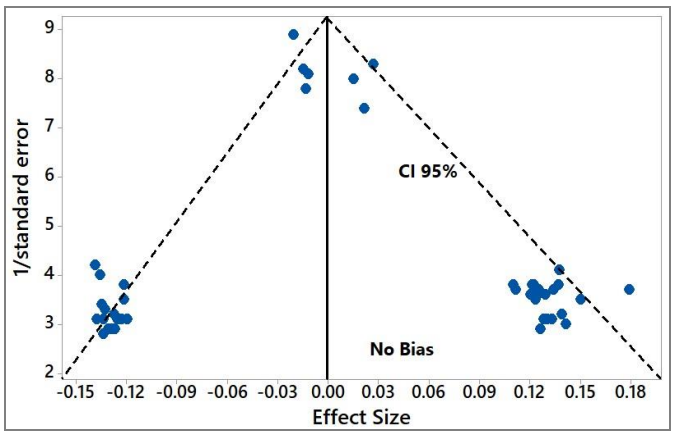
Figure 1. Selection of the articles.



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 Cohen's Test (d). The sample size was determined indirectly by the inverse of the standard error (1/Standard Error). This graph showed symmetrical behavior, not suggesting a significant risk of bias, both among studies with small sample size (lower precision) that are shown at the base of the graph and in studies with large sample size that are shown in the upper region.

Figure 2. The symmetrical funnel plot suggests no risk of bias among the studies with small sample size that are shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (NTotal = 43 studies evaluated in full in the systematic review).



Source: Own Authorship.

Major Results and Development

- **Parendodontic Surgery**

Parendodontic surgery combined with endodontics is a treatment option when the etiological agent of the periapical inflammatory process cannot be eliminated conservatively, i.e., through conventional endodontic treatment [11].

Furthermore, Bramante and Berbert (2000) [12] defined endodontic surgery as a surgical procedure performed to resolve difficulties arising from endodontic treatment. Therefore, the success of the surgery is higher when it is supplemented by root canal retreatment [13]. Periapical surgeries are given different names depending on the desired results [14]. For Cohen and Hargreaves (2007) [15], endodontic surgery is based on two objectives: the first is to remove the etiological factor, and the second is to prevent recontamination of periodontal tissues after removal of the etiological agent.

In this context, the main indications for endodontic surgery are anatomical complications, drainage, pain relief, iatrogenic problems, trauma, periodontal problems, the need for biopsy, foreign bodies in the apical region, incomplete or dilated apices, prosthetic procedures after endodontics, and failures or problems during treatment, such as root perforation, unlocated canals, material leakage, and non-regression of periapical lesions, among others [16].

Ideal planning for endodontic surgery requires some essential factors for the diagnosis and surgical maneuver of the lesion. Complementary examinations are essential to provide the quality of information necessary for lesion removal, such as size and extent, its relationship with nearby anatomical structures, and the state of bone involvement [17].

The failure rate of non-surgical endodontic treatments is highly significant when the treated teeth are located in oral regions where chemical preparation for surgery is not convenient, access by the dentist and/or endodontist is unfavorable for performing the septicnecrotic procedure, and the affected area of the teeth is difficult to access for the patient to maintain optimal quality of care at home [4-6].

Therefore, it is important to emphasize that periodontal surgery may be indicated for several dental procedures, such as [1-4]:

- ✓ The need for a biopsy of the periradicular tissue.
- ✓ When visualization of periradicular tissues is necessary in the face of a perforation or suspected fracture/crack;
- ✓ When drainage is required;
- ✓ When pain relief is required;
- ✓ When anatomical complications can be reduced;

- ✓ To correct and/or minimize iatrogenic problems;
- ✓ When trauma investigation is required;
- ✓ When problems resulting from initiated/completed endodontic treatments need to be resolved;
- ✓ When treatment needs to be addressed for defects resulting from previous treatment with or without a core.

The main contraindications for periodontal surgery include systemic disease and psychological considerations, dental factors, including bone or root configuration and lack of surgical access, and possible involvement of neurovascular structures where supporting tissue is poor [5-7].

Regarding the preoperative evaluation of periodontal surgery, dental procedures such as the procedure, planning, and the patient's general health condition must be taken into account before proceeding to a more in-depth secondary investigation of the case. It is essential to perform a complete patient history, focusing specifically on their underlying dental complaints, enabling greater interaction and exchange of data/information between the patient and the professional, conducting a thorough inspection of swellings, fistulas, areas with indicated sensitivity, percussion, perforation sites, among other local aspects, and performing periapical radiographic examinations [8].

Also, regarding periapical radiographic examinations, they are indicated as important in periendodontic surgery, as they are used to further evaluate the apical region, allowing for greater detailing of fistulas [7]. It has been reported that, in the dental setting, digitalized radiography has also been used as a diagnostic basis for apical pathologies. It is worth noting that Computed Tomography (CT), especially Cone Beam CT, is recommended as it provides higher-quality images and diagnostic efficacy [10].

After planning the surgical procedure, the surgical sequence should be devised, which should include anesthesia, incision, divulsion, osteotomy, curettage, drying, intraoperative radiography, and suturing [9,10]. Apical repair is emphasized, emphasizing the possibility of performing it in persistent post-endodontic lesions through simple apical curettage, in procedures where the extravasated material is beyond the apex or when fractured instruments in the area present painful symptoms or lack apical repair [7].

Lopes and Siqueira Júnior (2015) [18] disagree with the above, dictating that whenever endodontic surgery is chosen, apicoectomy should be performed, since neglecting this phase would be neglecting the causative agents of apical lesions that continue in the apical deltas, in the secondary canals, and in possible iatrogenic lesions generated by the endodontist, which, in the vast majority of cases, they are found in the apical portion of the roots, measuring approximately three millimeters.

Regarding the apical cut, the same authors mentioned above described that it has been performed at 30º and 45º for several years. However, currently, due to the advent of the surgical microscope and ultrasound tips, this angle has been reduced to 90º. The 90º apical cut and the use of ultrasound with angled tips allow the creation of a 3 mm-deep retrograde cavity [1].

Parendodontic Surgical Modalities

- **Surgical Drainage**

Odontogenic infections are one of the most difficult problems to treat and can range from well-localized infections that require only minimal treatment to severe infections in the fascial spaces that are life-threatening [19,20]. The immune response plays a fundamental role in defense against infectious agents and is the main impediment to the occurrence of disseminated infections, which are usually associated with a high mortality rate [1,21]. In this sense, odontogenic infections are related to periapical infections, resulting from pulp necrosis and subsequent bacterial invasion of periapical tissue, and periodontal infections, resulting from a deep periodontal pocket, which allows the inoculation of bacteria into the underlying tissues [2,3,20].

The main objective is to eliminate the causative agent, drain pus, and debridement or remove necrotic debris. Local treatment reduces the bacterial population, reduces tissue tension by improving blood flow, improves local conditions for the action of host defenses, and facilitates the delivery of antibiotics [22].

In this regard, surgical treatment is a fundamental step in the initial approach to patients with dentoalveolar abscesses and severe cellulitis. In mild to moderate cellulitis, in healthy patients, there is no need for drainage, as only eliminating the cause with associated antibiotic therapy will promote the involution of the process. The incision should be performed at the point of fluctuation, as far inferiorly as possible, perpendicular to the direction of the muscle fibers, and wide enough to allow effective drainage and encompass all involved spaces [5-7].

The general rule is an incision per affected space to obtain adequate drainage and involve only the skin and subcutaneous tissue or oral mucosa. These infections can become difficult to treat when associated with some systemic alteration that reduces the effectiveness of the patient's immune cells [3,4].

- **Periradicular Curettage**

Periradicular curettage consists of the removal of pathological tissue or foreign bodies (extravasated filling material and instrument fragments) from the apical area that is interfering with healing [12]. Curettage, or periradicular curettage, consists of the surgical removal of periapical tissue without reducing the length of the root. It is a surgical procedure aimed at removing pathological tissue from a lesion at the apical level of a tooth or foreign bodies in the periapical region [1].

In some situations, such as pulp necrosis and periradicular lesions, a periapical biofilm forms that is difficult to eliminate with conventional endodontic procedures and medications. This layer is colonized by bacteria, which can perpetuate the periradicular lesion. Therefore, periapical curettage must be performed to remove the microbial biofilm [23]. Furthermore, periapical curettage is a very important procedure, since it allows the removal of infected, contaminated, and necrotic pathological tissues. Histopathological analysis of the biological material removed by curettage is essential for establishing a correct diagnosis of the disease [24].

This can promote drainage of secretions and pain relief, in addition to addressing anatomical alterations, iatrogenic problems, trauma, endodontic and periodontal defects, and failures in previously performed treatments. It is also possible to circumvent issues such as the need to provide biopsy material [25].

- **Apicoectomy**

Apicoectomy is a surgical procedure recommended by numerous authors to eliminate apical deltas, which are not always visible on radiographs and may be contaminated or harbor necrotic material. These ramifications of the main canal have been cited as an important cause of failures after endodontic treatment [3,10].

Apicoectomy is the surgical removal of the apical portion of a tooth. It is indicated in numerous clinical situations, such as persistent periapical lesions that persist despite conventional treatment, perforations, fractured instruments, and removal of apical deltas [26]. The root is cut with a truncated cone bur, positioned perpendicular to the root axis, cutting as little as possible and cutting from distal to mesial in an insertion and removal motion, as if sawing the root [10].

It is important to note that the bur must be cooled by irrigating with saline solution, avoiding overheating, which can lead to necrosis of the dentin and cementum in the apical region, with future resorption of these structures. Once the cut is complete, the root tip structure is smoothed using a Bramante-type apical file, aiming to give it an anatomy close to the original. The gutta-percha, which is present inside the canal, should be slightly heated and condensed inside it, remaining 1.0 mm from the extreme cut. This prevents the guttapercha from being extruded from the root level if apical resorption occurs [10,19].

- **Surgery with Simultaneous Root Canal Obturation**

Simultaneous root canal obturation involves the three-dimensional obturation of the root canal concomitantly with surgical exposure of the tooth apex. This surgical modality represents an important resource to be used within endodontic surgery, provided it is well indicated [23].

In this regard, simultaneous root canal obturation during surgery resolves those stubborn cases of extensive chronic periapical lesions, in which, in addition to the root canal being well-instrumented, several dressing changes have already been made with calcium hydroxide paste, systemic antibiotic therapy has been administered, and yet, persistent inflammatory exudate is still present, preventing the case from being concluded [27,28].

Surgical exposure of the apex facilitates root canal biomechanics, allowing for more efficient obturation, with vigorous condensation without the concern of filling material leakage. Removing the pathological material from the periapex creates a canal free of exudation, allowing for complete obturation and regeneration of the supporting tissue.

Surgical access to the apex allows for the removal of foreign objects in the region, such as extravasated filling material or fractured instruments, or even the removal of the fractured root apex [10,28]. Retrograde Filling Retrograde obturation is a technique indicated in cases of inaccessibility via the coronal route, obstruction by a metal core, instrument fragments, filling material, instrumentation defects, anatomical malformation, and internal resorption. These alterations impede access to the root canal, compromising simpler paraendodontic surgeries, such as apicoectomy [10].

The retrograde obturation technique consists of resecting the apical portion of the root, followed by creating a cavity and filling it with a retrograde filling material [9]. Apical preparation removes residual irritants from the apical portion of the canal. It can also be performed with rotary instruments or ultrasonic tips. There is a high success rate when the retrograde cavity is performed with ultrasound. Ultrasonic tips offer advantages in control and ease of use, and sometimes allow for less apex removal [9,10].

According to Chandler and Koshy (2002) [29], ultrasonic retropreparation addresses the main shortcomings of conventional preparations. The root

canal filling material should hermetically seal the sectioned apex and trap any remaining irritants within the canal system, promoting apical cementogenic repair. The root canal filling material should be placed deeper than the most coronal limit of the bevel so that the exposed dentinal tubules in this area communicate with the root canal filling material and not with the root canal, minimizing apical leakage.

- **Retroinstrumentation with Root Canal Filling**

Retroinstrumentation combined with root canal filling is one of the surgical modalities used, in which the instrumentation and obturation of the root canal are performed apically. It is primarily used in teeth with periapical lesions whose canal is poorly sealed and inaccessible by conventional approaches [30,31].

In this context, Bramante et al. (1992) [32] presented a retroinstrumentation technique with retrofilling in which, after apical instrumentation with endodontic files, retrofilling is performed with a gutta-percha cone, selected according to the canal diameter, and surrounded by the sealer of choice. Thus, retroinstrumentation with retrofilling is indicated when access to the root canal system is inaccessible through conventional routes, with a considerable length of the root canal remaining unprepared and/or unfilled. By seeking to take advantage of the good biological and physicochemical qualities of sealers containing calcium hydroxide or calcium oxide in their composition, we believe that they would be of great use in endodontic surgeries [10,32].

- **Retrograde Instrumentation with Retrograde Obturation Associated with Retrograde Obturation**

To achieve a better apical seal and, at the same time, seal the largest possible extension of the root canal, Bramante, Berbert, and Bernardinell (1992) [32] proposed combining the retrograde filling technique with retrograde filling. The advantage of this technique over the previous one is that it corrects any defects that have persisted with retrograde filling.

It is performed to achieve a better apical seal than retrograde filling alone or retrograde instrumentation with retrograde filling. After instrumentation and obturation of the canal, a retrograde cavity is prepared at the site corresponding to the canal and sealed with retrograde filling material. This method is superior to the previous one because it provides a double seal in the apical region [19].

The purpose of using a root-end filling material is to seal or seal the remaining root prevents infiltration or the migration of microorganism residues to the periapex. The rootend filling material must have ideal characteristics such as being non-toxic, non-mutagenic, biocompatible, and insoluble, good adhesion to tooth structure, long-lasting sealing capacity, easy handling, radiopaque, dimensional stability, and not altering in the presence of moisture [33].

In the retrograde filling technique, the gutta-percha cone is passively placed in the canal, making the marginal seal dependent on the adaptation of the filling cement between the gutta-percha cone and the canal walls. However, in retrograde filling, the condensation of the retrograde filling material on the apical cavity is more effective, which can be related to its better sealing capacity [9].

- **Canalization**

Canalization is a surgical modality, a variation of retrograde filling, and is indicated for cases in which, due to excessive instrumentation at the apical level, there is a large loss of the vestibular wall of the canal and in which apicoectomy, with a very extensive cut of the root, could compromise the stability of the tooth [19].

In the presence of severe instrumentation deviation and in cases of perforations in the form of tears, another retrograde sealing technique, known as canalization, is indicated. It is performed by removing the vestibular wall of the root canal and creating a retrograde Class II canal cavity. This cavity will be filled with retrograde filling material [9,10].

- **Rhizectomy**

Root amputation can be defined as the act of removing one or more tooth roots through surgical procedures performed on teeth implanted in their sockets. The surgical procedure of root amputation involves removing one or more roots to eliminate the disease while preserving the tooth [34].

According to Berger (2018) [19], this technique is indicated when one of the roots is compromised by a large cervical perforation, cervical resorption, or significant bone loss, and the tooth is part of a fixed prosthesis. This technique requires endodontic treatment of the affected tooth, which should preferably be performed before resective surgery. However, since there are no morphological changes in the crown, this type of procedure does not necessarily require subsequent prosthetic reconstruction.

- **Odontosection**

This is a procedure widely used in periodontics and has the same indications as rhizectomy. In this case, however, the root and crown are sectioned, transforming, for example, a molar into a premolar. It is also indicated for multi-rooted teeth. In the case of

lower molars, the mesial or distal root is removed, depending on the affected root. In upper molars, the mesiobuccal or distobuccal root is generally removed, also depending on the affected root [3,4].

- **Surgical Treatment of Cysts**

Cystic lesions are treated in two ways: endodontic (conservative) and surgical treatment, the latter divided into enucleation, marsupialization, and decompression. Endodontic treatment is often limited to the resolution of small cystic lesions or as a means of partial regression of the lesions for subsequent surgical treatment. Enucleation, on the other hand, is a way to completely eliminate the lesion in a single surgical procedure [35,36].

Decompression and marsupialization are a single step toward definitive treatment, the main objective of which is to reduce the cyst for subsequent enucleation [36]. Enucleation consists of the complete removal of the cystic lesion without rupturing the fibrous capsule. This technique must be performed with caution, as removing the entire lesion reduces the chances of recurrence. Its main advantage is that it allows for complete histopathological examination of the lesion and provides appropriate treatment [37]. It is a method by which the cystic lesion is moved, in its entirety, without rupture. It is the treatment of choice and should be used for any type of jaw cyst that can be removed without unnecessarily sacrificing adjacent structures.

The treatment of large radicular cysts (> 3 cm) consists of the marsupialization technique. This involves creating a surgical window in the cyst wall to empty its contents and maintain continuity between the lesion and the oral cavity, maxillary sinus, or nasal cavity. This process reduces intracystic pressure and promotes lesion regression and new bone formation [38].

It is indicated in situations where there is a risk of injury to vital structures (vessels, nerves, among others) and neighboring teeth, as well as when there is a possibility of weakening bone structures. The surgical technique is considered simple: a generally circular incision is made, creating a wide window to connect the lesion with the oral cavity. This incision is sutured to the adjacent mucosa. Removing part of the lesion capsule provides material for histopathological examination [39-43].

Limitations

Although the success rate of periodontal surgery is considered high, especially with microsurgery, there is still a lack of randomized controlled clinical studies with larger sample sizes to demonstrate better clinical outcomes and more robust patient follow-up.

Conclusion

It was concluded that the success rates of parendodontics surgeries depend on the surgical modality indicated, the type of retrofilling materials used, the quality of the root canal filling prior to surgery, the treatment of surgical pockets, the execution of surgical techniques, and the periodontal conditions. The success of the surgery is higher when it is supplemented by root canal retreatment. Parendodontic surgery aims to remove the etiological factor and prevent recontamination of periodontal tissues after the etiological agent has been removed. The main indications for periodontal surgery are anatomical complications, drainage, pain relief, iatrogenic problems, trauma, periodontal problems, the need for biopsy, foreign bodies in the apical region, incomplete or dilated apices, prosthetic procedures after endodontics, and failures or problems during treatment.

CRediT

Author contributions **Conceptualization-** Anaísa Souza Camilo Aguiar, Thais Cabelo de Oliveira; **Formal Analysis-** Anaísa Souza Camilo Aguiar, Thais Cabelo de Oliveira, Oscar José Pires; **Investigation-** Anaísa Souza Camilo Aguiar, Thais Cabelo de Oliveira; **Methodology-** Anaísa Souza Camilo Aguiar, Thais Cabelo de Oliveira; **Project administration-** Anaísa Souza Camilo Aguiar, Thais Cabelo de Oliveira; **Supervision-**Oscar José Pires; **Writing - original draft-** Anaísa Souza Camilo Aguiar, Thais Cabelo de Oliveira, Oscar José Pires; **Writing-review & editing-** Anaísa Souza Camilo Aguiar, Thais Cabelo de Oliveira, Oscar José Pires.

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Conflict of Interest

The authors declare no conflict of interest.

Similarity Check

It was applied by Ithenticate®.

Application of Artificial Intelligence (AI)

Not applicable.

Peer Review Process

It was performed.

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