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Endodontic surgery: Influencing factors

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Abstract
Introduction: Periapical surgery has been indicated for the treatment of teeth with periapical lesions when disease persists despite orthograde periapical root canal treatment, a surgical approach may be indicated when periradicular pathosis cannot be resolved with a non-surgical approach.
Objective: To analyze the literature on influencing factors on endodontic surgery, particularly surgical considerations, root-end preparation, root-end filling, and treatment success.
Methodology: The search for articles was performed by a researcher in the Pubmed database. Keywords used were "endodontic surgery", "apicoectomy", "flaps", "osteotomy", "preparation of the root or apical end", "retrograde obturation" and "treatment success of endodontic surgeries".
Results: The surgical considerations, such as that the flaps can be full thickness or divided and a fundamental part is to achieve a good esthetic in the healing. In the osteotomy the important thing is the diameter in which it is performed, the larger the diameter, the more the healing process will be. Then a resection of the root end will be performed, mainly the apical 3 mm and 3 mm intraconducts will be prepared in a retrograde way with ultrasound tips. The obturation will be performed in a retrograde way where the most used materials for this step in the procedure are MTA and Biodentine. The success rate of this treatment is over 80%.
Conclusion: Endodontic surgery treatment is a highly complex and complicated procedure. In order to perform this treatment, good planning with CBCT studies should be carried out.

Keywords: Endodontic surgery, apicoectomy, flaps, osteotomy, retrograde obturation

1. Introduction

Traditionally, periapical surgery has been indicated for the treatment of teeth with periapical lesions when disease persists despite orthograde periapical root canal treatment [1]. For this purpose, non-surgical endodontic treatment is the first choice in most cases, but a surgical approach may be indicated when periradicular pathosis cannot be resolved by a non-surgical method [2]. In particular, only surgical intervention can resolve cases involving a persistent lesion with etiology related to complex canal anatomy, extraradicular infection, foreign body reaction material and/or cystic tissue [3]. Large cross-sectional studies from several countries have indicated that the prevalence of apical periodontitis and other post-treatment periradicular diseases may exceed 30% of the entire population of root-filled teeth. These facts recommend an important requirement for the treatment of this condition [4]. The surgical approach comprises several sequential procedures in order to meet the aforementioned objectives: (a) periapical resection (apicoectomy), (b) preparation of the root cavity, and (c) sealing of the root canal system using a bioactive and placement of biocompatible filling material at the root end [5]. The success rate of this surgical procedure is approximately 91.9%, and is largely attributed to the preparation of a retrograde cavity that allows a correct marginal adaptation of the material in the three dimensions of the space, ensuring a correct sealing of the root canal and avoiding microleakage of microorganisms into the periapical tissues [6]. The introduction of the dental operating microscope in the early 1990s led to a new era in modern surgical endodontics [7].

This research was conducted mainly to understand more about this type of treatment where more innovative and materials are used.

Characterized by surgical techniques, which not everyone can perform them due to lack of knowledge. The objective of this review is to analyze the literature about influencing factors on endodontic surgery, particularly surgical considerations, root end preparation, root end filling, and treatment success.

2. Materials and methods

Articles on the subject published through the PubMed, SCOPUS and Google Scholar databases were analyzed, with emphasis on the last 5 years. The quality of the articles was evaluated using PRISMA guidelines, i.e., identification, review, choice and inclusion. The quality of the reviews was assessed using the measurement tool for evaluating systematic reviews (AMSTAR-2). The search was performed using Boolean logical operators AND, OR and NOT. It was realized with the words "endodontic surgery", "apicoectomy", "osteotomy", "retrograde obturation", "clinical success". The keywords were used individually, as well as each of them related to each other.

3. Results & Discussion

3.1 Surgical considerations

3.1.1 Flap design

Flap design is of vital importance in endodontic surgery. It affects access, visibility, anatomical structures, repositioning and suturing [8]. In contemporary dentistry, the goal of successful periradicular surgery is not only functional retention of teeth but also to achieve optimal pink esthetics. The term pink esthetics denotes that the appearance, color, texture, papilla height and gingival position of neighboring soft tissues should appear natural and healthy [9]. Several flap designs have been recommended in the literature. These include marginal incision, submarginal incision and a combination of both. Marginal incision involves raising a full-thickness sulcular flap of any design with or without a vertical release incision. Submarginal flaps can be crescentic in shape or with a scalloped design also known as an Ochsenbein-Luebke flap [10]. There is another flap that is a combination of marginal and submarginal incision called a papilla-sparing flap or papilla-based incision. It preserves the base of the papilla in the interdental area and becomes a sulcular incision in the cervical area of the affected teeth [11].

Although some authors have suggested split-thickness flaps, almost all flaps are either full-thickness or varying thickness. Full-thickness flaps are divided into complete groups, shown as sulcular, triangular and rectangular (or trapezoid), and incomplete, presented as semilunar, scalloped submarginal, straight submarginal and vertical [12].

Modern microsurgery is using the triangular flap with 1 vertical incision, the papilla base incision for papilla preservation and the Luebke-Ochsenbein submarginal flap. The latter is the most commonly used. The esthetic flap design especially in the maxillary anterior area is performed within the attached gingival area and results in almost no recession of the gingival margins and interdental papillae postoperatively [13].

3.1.2 Osteotomy

Osteotomy is becoming increasingly conservative due to the higher magnification and illumination offered by the microscope. The diameter of the osteotomy is only 3 to 4 mm, enough for a 3-mm ultrasonic tip to vibrate freely within the bone cavity. To prepare a small osteotomy, the exact position of the root apex must be identified [14]. Evidence has accumulated showing that the larger the defect, the lower the chance of complete healing. A direct relationship was shown between the size of the osteotomy and the speed of healing: the smaller the osteotomy, the faster the healing. In fact, in microsurgery of the mandibular first molar, an osteotomy of 3 to 4 mm in diameter is sufficient to leave room for a 3 mm ultrasonic tip [15]. Recently, preservation of the cortical bone plate, the so-called bone window technique, has been attempted using a piezoelectric saw. With this conservative technique, the removed cortical bone plate can be repositioned at the original site. The piezoelectric instruments ensure selective, precise and safe cutting of the bone, and the air-water cavitation effect provides better visibility by creating a clear and blood-free surgical field [16]. A clinical study on healing, evidenced by radiographic changes, showed that there is a direct relationship between osteotomy size and healing speed: the smaller the osteotomy, the faster the healing. For example, a lesion smaller than 5 mm would take an average of 6.4 months, a lesion between 6 and 10 mm requires 7.25 months and a lesion larger than 10 mm requires 11 months to heal.

As a conclusion it is mentioned that these 2 surgical steps are of vital importance to be able to perform apical surgery, where the flaps depending on the piece, the area and the operator will decide if a full thickness or divided flap is required and to achieve a good esthetic healing. In the osteotomy the important thing is the diameter in which it is performed, the larger the diameter the more the healing process will be. The ideal diameters are 3 to 4mm.

3.2 Root end preparation

If nonsurgical root canal treatment followed by retreatment attempts is unsuccessful, surgical periapical surgery followed by root end resection and periapical sealing may be needed to save the tooth. When performing root end resection, at least 3 mm of the root end should be cut to reduce 98% of the apical ramifications and 93% of the lateral canals [17]. Ultrasonic instruments are used for root-end cavity preparation. They are now highly recommended as the coated tips cut dentin and filling material much faster than stainless steel [18]. Ultrasonic tips present an alternative to conventional rotary drills and show several advantages when used to perform root-end preparation. In fact, the advent of ultrasonic tips resulted in the improvement of root-end preparation, mainly due to the availability of tips with different shapes and angulations, which are meticulously selected according to the characteristics and location of the root [19]. Ultimately, ultrasonic preparation results in root-end cavities that are smaller, cleaner and more retentive, as well as more centrally located and aligned with the direction of the original root canal [20]. In addition, the modern technique uses a shallow bevel angle of 0° to 10° to expose fewer dentinal tubules with improved magnification and illumination techniques [21].

Higher clinical success rates were reported when root-end preparation was performed with ultrasonic tips instead of the classic rotary bur approach [22]. However, the incidence of apical microcracks after root-end preparation with ultrasonic tips has been reported [23]. Nevertheless, with the aim of improving ultrasonic results with regard to microcrack formation after apical preparation, new diamond-coated tips have been introduced. The production of novel ultrasonic diamond-coated tips, such as CVDentus tips, was achieved with the aim of obtaining tips with higher cutting efficiency, which would therefore require less preparation time, possibly reducing the incidence of fractures [24].

In conclusion, we obtain that in this procedure also known as

apicoectomy, a resection of the root end will be performed, mainly the apical 3 mm, because that is where the apical ramifications and lateral canals are located. After this resection, 3mm intracondylars are prepared in a retrograde way with ultrasound tips, which have different angles and shapes for a better fit depending on the dental piece, to proceed with the material in its retrograde placement.

3.3 Root end filling

An ultrasonically prepared root end cavity should be filled with a material that ensures a bacteria-tight seal. Several materials have been suggested for this purpose [25]. An excellent root-end filling material should possess good biocompatibility, excellent sealing ability, the desirable ability to inhibit pathogenic microorganisms and a predominant ability to promote healing of periapical tissue [26]. Biocompatibility of dental materials is essential to avoid significant inflammatory reactions and to allow repair. A biocompatible material should exhibit low toxicity without promoting an inflammatory reaction, which should be mild or not significant when present. The material can be considered biocompatible if the inflammatory reaction is reduced to non-significant levels within a reasonable period of time, such as 14 days [27].

There are three material-related properties that could influence the quality of the retrograde filler: micro- and nano-porosity and wettability [28]. The main characteristic of tricalcium silicate-based cements is the precipitation of apatite carbonate in the presence of tissue fluids, followed by the formation of an interface that consolidates the bond between the biomaterial and the root dentin, favoring bond strength, minimizing the presence of spaces and reducing permeability. Regarding the first of the properties mentioned, bond strength is defined as the bonding process between two surfaces with different molecular composition as a consequence of chemical, physical or mechanical forces, and is influenced by the characteristics of the medium in which it is applied [29]. Several attempts have been made to improve the handling capability by modifying the material properties. Biodentine (Septodont, St. Maurdes Fossés, France) is an MTA-based castable material containing a liquid water-soluble polymer, which reduces the viscosity of the cement and thus improves handling. Therefore, Biodentine can be easily applied with conventional instruments such as plugs [30]. The results showed that Biodentine showed stronger sealing ability than MTA and both could promote bone regeneration after 6 months [31]. Significant differences in patency were observed for Biodentine and MTA at days 2, 10 and 28. At the first time point, the results were favorable for Biodentine, although at days 10 and 28 the findings were favorable for MTA, with the lowest leakage rate [32].

In conclusion, the materials most commonly used for this step in the procedure are bioceramic cements, the main ones being MTA and Biodentine, which should have good biocompatibility, excellent sealing capacity, the desirable capacity to inhibit pathogenic microorganisms and a predominant capacity to promote healing of the periapical tissue.

3.4 Treatment success

Bioceramic obturation materials for root tips have been shown to have success rates of 86.4 to 95.6% (over 1 to 5 years) [33].

Of 652 cases in the cohort, 225 (34.5%) were included. The mean follow-up period was 90.4 months (range, 60-168 months). The long-term success rate was 80.5% and the 5-year survival rate was 83.5% [34]. For the preoperative clinical factor, maxillary and mandibular anterior teeth were reported to have higher cure rates, which can reach 85%, and mandibular molars with a relatively lower cure rate. These results may be related to the access for the surgical approach, the complexity of the root canal anatomy, the presence of isthmus, the axis of root canal preparation, etc [35].

In another study, they evaluated success rates in 90 teeth that received a retrograde filling material (ProRoot MTA). During a follow-up period of two and six years, the results were considered cured (complete healing of the anterior radiographic rarefaction or incomplete healing of scar tissue and absence of clinical signs/symptoms) which accounted for 80% of the cases, not cured was present in 14.4% (no reduction or even enlargement of the anterior rarefaction, or presence of clinical signs or symptoms), and uncertain in 5.6% (clinical normality with some reduction of the anterior radiolucency) [36].

In other investigation, 187 patients and 234 teeth submitted to apical surgery were included. Fifty-three male and 134 female patients were analyzed. The age ranged from 17 to 89 years and the mean age was 43.64 years. Better healing rate was observed with significant differences in patient ($p< 0.05$), age ≤ 60 years ($p< 0.01$), preoperative root canal filling material > 2 mm below the apex ($p< 0.01$), lesion size ≤ 2 mm to ≤ 12 mm ($p< 0.05$) and follow-up period ≧ 12 months ($p< 0.01$) to the groups [37].

Twenty-nine single-rooted teeth (in 29 patients) presenting periapical pathology after correct endodontic treatment were analyzed. At the end of the study, clinical success was achieved in 17 patients (58.6%), who had no symptoms, and 16 (55.2%) showed a radiographic image with complete bone regeneration (complete healing) [38].

The overall success rate was 88.4%. With regard to the variables evaluated, only one parameter (type of tooth) was found to be statistically significant [39]. Endodontic surgery with the aid of an endoscope is associated with high success rates (88.9-94.9%) [40].

In conclusion, this procedure should be performed as one of the last options, regardless of its high success rate, where the literature mentions that the success rate is above 80%.

4. Conclusion

Endodontic surgery is a procedure has to be left as a last option due to its complexity. In order to perform this treatment a good planning must be done, as of the flap to be performed in order to avoid a bad scarring. The osteotomy should be approached in small diameters, the apicetomy in the apical 3mm, the retrograde preparation with ultrasound tips with the ideal angulation of the tooth and the material for retrograde filling such as MTA or Biodentine, the success of this procedure is high.

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