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An update on guided endodontics

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Abstract
Introduction: In 2016, a new approach to endodontics using CAD/CAM printed guides or splints emerged, mostly in pieces with pulp obliteration.
Objective: To analyze the literature on some current endodontic techniques for the treatment of pulp obliteration, such as static guided endodontics, dynamic guided endodontics, and guided endodontic microsurgery.
Methodology: PubMed, SCOPUS and Google Scholar databases were reviewed to find recent articles published on guided endodontics with the following keywords: "pulp obliteration", "CBCT", "static guided endodontics", "dynamic guided endodontics" and "guided endodontic microsurgery".
Results: Pulp obliteration is the narrowing of the dental pulp space, which is caused by extrinsic and intrinsic factors. CBCT helps to measure the path of the canal in the dental roots, in order to be able to perform the appropriate accesses in endodontics. Static-guided endodontics, also called Endo Guide, uses 3D printed directional guides made with CBCT and CAD/CAM. Dynamic guided endodontics combines images that are reproduced in real time, guiding access and angulation. Microsurgery is performed when there is a failure in root canal therapy, its success rate has been increasing thanks to the use of CBCT that helps to link the other techniques using templates that predict the procedure.
Conclusions: Pulp obliteration causes pulp sclerosis and necrosis which at some point will require root canal treatment, currently different techniques can be used such as static guided endodontics, dynamic guided endodontics, microsurgery in which they have to go hand in hand with the use of CBCT for planning, the choice of these depends on the complexity of the case.

Keywords: Guided endodontics, pulp obliteration, CBCT, dynamic endodontics, static endodontics, endodontic microsurgery

1. Introduction
Pulp obliteration (PO) is a typical late sequela after dental trauma. They occur in 15% to 40% of cases after luxation injuries [1]. Endodontic therapy is indicated in 7% to 27% of OP cases when apical periodontitis or acute symptoms are present [2]. The combination of dental surgical microscopy and an ultrasonic tip can be used to identify obliterated canals however the treatment of teeth with PO is time consuming [3]. Therefore, treatment of teeth with pulp canal obliteration presents a challenge given the high probability of procedural errors and complications during their procedure [4]. In 2016, a new approach to endodontics using three-dimensional (3D) printed guides or splints mostly used in PO teeth emerged [5]. Cone beam computed tomography (CBCT) devices and software, associated with digital planning and 3D printing resources, allowed the advent of guided endodontics [6]. Currently, there are different types of guided endodontics: static guided endodontics (SGE) and dynamic guided endodontics (DGE) [5]. This 3D information can be combined with tooth surface information acquired with an intraoral scanner to design and 3D print a treatment guide [7]. Guided endodontics may be a promising method for endodontic or surgical treatment of complex cases [8].

The aim of this research is to analyze the literature on the various current endodontic techniques for the treatment of pulp obliteration, such as use of CBCT, static guided endodontics, dynamic guided endodontics, and guided endodontic microsurgery.

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 guidelines, i.e., identification, review, choice, and inclusion. The quality of the reviews was assessed using the measurement tool for evaluating systematic reviews. The search was performed using Boolean logical operators AND, OR and NOT, with the keywords: pulp obliteration, CBCT, static guided endodontics, dynamic guided endodontics, and guided endodontic microsurgery.

3. Results and Discussion

3.1 Guided endodontics to treat pulp obliteration

Guided endodontics is a novel approach used in the management of obliterated root canals, autotransplantation and periradicular surgery, this can be static or dynamic [9]. This new approach requires more planning time, due to possible inaccuracies of preoperative CBCT and intraoral scanning [10]. Pulp canal obliteration, is associated with luxation injuries of teeth or adults, is characterized by a gradual, progressive, and excessive deposition of reparative dentin within the root canal walls [11]. Root canal calcifications have several synonyms and etiologies elaborated in the literature, some of which are pulp lumen reduction, dystrophic calcification, pulp calcification, calcified pulp obliteration, and pulp canal sclerosis [12]. Often, the affected tooth shows discoloration of the clinical crown that becomes darker this is the result of increased dentin thickness, leading to reduced crown translucency [13]. PO is seen radiographically as a rapid narrowing of the pulp canal space; late development of pulp necrosis and periapical disease are rare complications after PO [14]. Local and systemic factors can contribute to the formation of dental pulp calcification, excessive forces, presence of restorations, cavity preparation and caries are common local factors [15]. Within the PO, pulpal calculi may exist, which are calcified nodular masses found in the coronal or root portion of the pulp. They are usually oval or round in shape and can also be irregular [16].

Pulp obliteration has been described in the literature as the narrowing of the dental pulp space, which is caused by various factors that can be extrinsic: restorations, excessive forces, or intrinsic factors: preparation of the cavity by caries, causing pulp sclerosis and necrosis which at some point will require root canal treatment, which can currently be performed using the guided endodontic approach.

3.2 Application of CBCT in guided endodontics

CBCT is a radiographic imaging technique that creates a three-dimensional image of the exposure site. Developed in the early 1990s, it is increasingly used in dentistry for a variety of indications [17]. The application of this technology ranges from implant design, periodontal defects, endodontics, and orthodontics, as well as in maxillofacial practice [18]. Accurate jaw segmentation from CBCT is an important step in constructing a customized 3D digital jaw model for maxillofacial surgery and orthodontic treatment planning due to the low radiation dose and short scan duration [19]. The known limitations of periapical radiographs in clinical diagnostics have encouraged practitioners to recommend CBCT imaging examinations [20]. It provides more accurate and detailed information about the anatomical structures of a root canal system, which has a positive impact on outcomes by improving predictability [21]. Within surgical endodontics, it plays an important role as it helps to measure the distance between the cortical plate and the apex, the position of the roots within the bone and the proximity of vital structures [22]. CBCT imaging allows locating the visible part of the root canal and planning the access route to the root canal system while preserving the cervical dentin [23]. CBCT applications in endodontics involve the shift from analog to digital imaging and advances in imaging theory and volume acquisition data, allowing detailed 3D images [24].

Cone beam tomography studies have been introduced since the 1990s in dentistry, being useful for implant procedures, orthodontics, maxillofacial surgery, and more recently for guided endodontic treatments. The CBCT helps to improve predictability in these treatments, in endodontics it helps to measure the path of the canal in the dental roots, to be able to make the appropriate accesses in an endodontic treatment.

3.3 Types of guided endodontics

3.3.1 Static guided endodontics

The 3D endodontic guide or Endo Guide is a template made to guide drills in predetermined positions to locate and explore root canal orifices or bone trepanation and root end resection [25], these templates use stereolithography templates to realize the access cavity [26]. In this guide, a drill hole can be designed with a specific diameter and angulation to allow direct access to the calcified canal, then cylinders can be designed, this can be smaller and is made of metal, once the designs are finalized, the file is exported from the planning software [27]. Directional guides are designed in 3D made with CBCT and CAD/CAM allowing the design of the drill with a specific diameter and angulation, this benefits the dentist to perform the drilling accurately in the original direction of the root canal [27]. Inaccurate endodontic access cavities can lead to intraoperative complications, such as overextended access cavities, crown perforation, root perforation, lost root canals, fracture of root canal instruments [28]. This technique in a 2018 study yielded results in which it reduced excessive loss of tooth structure and chairside operating times were shorter, in addition, the use of one or two drills ensured the accuracy of the drilling procedure [29]. Static guidance can only be performed on roots or straight parts of curved roots. In addition, it requires more time for planning and the radiation dose is increased due to mandatory CBCT [30]. Static-guided endodontic technique can provide advantages to the clinician for MTA removal [31]. On the other hand, the disadvantage is that it requires the template fabrication step and, therefore, patients with severe pain may not be treated quickly [32].

Static guided endodontics allows the design of a directional guide through software that plans and designs the drilling with specific data, in terms of angulation and diameter, resulting in direct access with less attention time by the dentist and a high accuracy rate in drilling the template, which help to reduce risks such as instrument fractures or overextended drillings.

3.3.2 Dynamic guided endodontics

Dynamic navigation system (DNS) has been used for both surgical and non-surgical endodontic therapies using an optical tracking device managed by a special computer interface, DNS combines CBCT and spatial positioning technologies [33]. There are studies mentioning that dynamic navigation technology can achieve high positioning accuracy in the depth range up to 15 mm, but its deviation increases as the depth gets deeper [34]. DNS is based on the use of CBCT images with reference marks that are placed in the patient's mouth on the side opposite to the side to be operated on to position the access path to the pulp chamber and root canal [1]. DNS requires an optical triangulation tracking system that uses real-time stereoscopic motion tracking cameras to guide the drilling process according to the planned angle, path, and depth of the endodontic access cavities [35].

The technique of dynamically guided endodontics is combined with the use of CBCT using images that are reproduced in real time, which are followed in motion cameras in a stereoscope that guide the access, angulation and depth, which in studies mentioned that has a high accuracy at a depth of 15mm, one of its advantages unlike static guided endodontics is that no templates are required so that the patient can be treated in a faster way.

3.3.3 Guided endodontic microsurgery

Endodontic microsurgery is defined as treatment performed on the root apices of an infected tooth that did not resolve with conventional root canal therapy [36]. Surgical endodontic procedures include removal of necrotic and infected periapical tissues, resection of the apical part of the tooth (apicoectomy), and preparation of the root-end cavity for insertion of retrograde filling material [37]. Endodontic microsurgery in the mandibular molar area can be more challenging due to limited access, thickness of buccal cortical bone, complex root morphology, and proximity to the mandibular canal [38].

The success rate of endodontic microsurgery has increased from 44.2 to 53.5% to 90.5 to 91.1% with the advancement of CBCT and surgical instruments and materials [39].

Microsurgery is performed when there is a failure in canal therapy in a conventional way, so it is opted to perform an apicoectomy and retrograde obturation, its success rate has been increasing thanks to the use of CBCT that help to link the other techniques using templates that predict the procedure. There are not many studies describing the application of this technique.

4. Conclusions

Pulp obliteration has been described as the narrowing of the dental pulp space, causing pulp sclerosis and necrosis which at some point will require a root canal treatment, currently different techniques can be used as static guided endodontics that requires templates, dynamic guided endodontics that is performed in real time cameras, also microsurgery in which they have to go hand in hand with the use of CBCT for planning, the choice of these depends on the complexity of the case.

4.1 Conflict of Interest

Not available

4.2 Financial Support

Not available

5. References

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