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AN OVERVIEW THE EFFICACY OF MINIMALLY INVASIVE ENDODONTIC ACCESS CAVITY IN MOLAR TEETH ON POLYMERIZATION, FRACTURE RESISTANCE

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Abstract:
In the past decade, less intrusive access cavities have been suggested to minimize tooth tissue loss during endodontic procedures and to alleviate the diminished fracture resistance of endodontically treated teeth. The fracture resistance of molars with various access cavity designs may be influenced by restorative materials and age. There is a lack of comprehensive literature regarding

the influence of cavity design and restorative material types on restorative factors, including material adaptation and photo-polymerization in limited access cavities. This review evaluates the quality of polymerization, material adaptability, and fracture resistance in several types of recovered access cavities. The access cavity is a pivotal phase in root canal therapy and may affect the succeeding treatment phases. The novel minimally invasive endodontic access cavity preparation concept seeks to protect healthy tooth structure by retaining maximal intact dentin, including the roof of the pulp chamber, to prevent tooth fractures during and following endodontic treatment.

Introduction:

The enduring efficacy of endodontic treatment is influenced by an access cavity design that maximally conserves tooth structure, the quality of root canal procedures, the selection of an optimal restoration to address the loss of coronal tooth structure, and the application technique [1, 2]. For decades, conventional endodontic cavity designs, standardized for each tooth type, have remained largely unaltered, entirely eliminating the pulp chamber roof to identify root canals and establishing linear pathways into the canals to enhance the efficacy of instrumentation [1]. Conventional methods frequently eliminate substantial tooth material, jeopardizing structural integrity. Recent improvements emphasize the preservation of dentin and enamel, hence diminishing the risk of fractures and enhancing outcomes. A revolutionary approach of cavity preparation, known as minimally invasive access, is inspired by the principles of minimally invasive dentistry. It emphasizes the conservation of peri-cervical dentin and a portion of the pulp chamber roof referred to as "Soffit," with the access cavity design designated as "conservative access cavity" (CAC). A select group of endodontists has emphasized this concept by creating "Ninja" and "Truss" access cavities (NACs and TRACs). The Ninja access cavity (NAC) is a small aperture on the occlusal surface that allows the dentist to identify and access all canal orifices [3,4]. The truss access cavity (TRAC) provides direct access to each canal orifice from the occlusal surface, thereby obviating the necessity to remove the entire pulp chamber ceiling [5].

Review:

The clinician's convenience in access preparation is the cornerstone of conventional endodontic access design. During minimally invasive access cavity preparation, the healthy tooth structure existing in the coronal, cervical, and radicular regions is preserved to the maximum extent to enhance both short- and long-term success of the tooth. These designs necessitate the elimination and prevention of the illness to be executed without unnecessary tissue damage, hence enhancing the success rate of non-surgical endodontic treatment [6]. The cautious access preparation safeguards the existing tooth structure by minimizing the removal of dental material to extend the tooth's longevity. Numerous scholarly articles have delineated the typical methodology for preparing an access cavity. Consequently, we will further examine the minimally invasive technique for access cavity preparation [7].

The enamel is perforated from the central fossa to form an access chamber. It persists just until small files can identify the orifices. It is a succinct iteration of conventional access cavity preparation, as the designation suggests. The pericervical dentin, crucial for transmitting pressure from the occlusal table to the root and enhancing the fracture resistance of endodontically treated teeth, is preserved through the creation of this minimally invasive access cavity [8]. The preservation of more dentin by the reduction of cavity size resulted in enhanced fracture resistance of the tooth due to the benefits of a contracted access cavity preparation. Cavity preparation may elevate the likelihood of inadequate canal instrumentation and procedural mistakes, presenting a disadvantage. Moreover, the risk of bacterial contamination and the likelihood of overlooking some root canal openings escalates with the enlargement of the access cavity [9].

This preparation preserves the dentinal bridge between the mesial and distal canals or the buccal and palatal canals, solely to locate the canal orifices and prepare the root canals. This architecture is enhanced to allow access to each canal via a distinct orifice. The truss access, however, lacks standardization. Access to the pulp chamber is obtained from the occlusal surface to the roof of the pulp chamber by positioning the bur parallel to the long axis of the tooth in an oval configuration buccolingually with an Endo access bur. The bur is subsequently placed across the distal pulpal horn to access the pulp chamber. An access cavity is formed with a diverging wall by rapidly rotating an Endo Z bur within the pulp chamber. The primary emphasis of advantages lies on preserving healthy dental structure using a less intrusive technique. The preservation of the mesial and distal ridges significantly enhances the fracture resistance of teeth. Preservation of pericervical dentin. During the preparation of conservative access, the soffit is prepared [10,11].

Computer-assisted access cavity preparations

Establishing a reliable trajectory to the root canal space while conserving tooth structure necessitates the utilization of software and three-dimensional imaging. This computer-assisted method was originally created for implant insertion and is considered a form of minimally invasive access. This cavity preparation process is classified into two distinct kinds [12]. Passive optical technology, CBCT imaging, and software facilitate the dynamic navigation interface, which guides the bur's penetration into tooth structure in real-time to achieve the appropriate access cavity. The Guided Access cavity demonstrates that this technology requires minimal planning. The Dynamic Navigation Access preparation protocol necessitates many intraoral attachments prior to the initiation of the treatment plan. This apparatus is expensive. Recent publications in endodontics include several in vitro research and case reports that demonstrate the feasibility of computer-assisted access cavities [12,13].

Consequently, advancements in magnification, imaging techniques, and endodontic instruments have led to the development of conservative endodontic cavity designs, which prioritize the preservation of remaining tooth tissue during access cavity preparation, as an alternative to conventional endodontic cavity designs. In conservative endodontic cavity designs, the preference is for the removal of restorative materials rather of enamel or dentin, and the excision of occlusal structures instead of peri-cervical dentin. This method retains sections of the pulp chamber's roof while protecting the peri-cervical dentin, so sustaining the tooth's mechanical stability, ultimately extending its longevity and improving its functionality [14]. Nonetheless, conservative cavity designs may restrict adequate irrigation and instrumentation, obstruct root canals, and result in increased mistakes during endodontic procedures [14,15].

Numerous research have suggested novel, more conservative and ultraconservative methodologies for the preparation of endodontic access cavities, including the conservative, Ninja, and truss access designs [12, 15]. The Ninja endodontic access cavity design entails creating a small aperture from the central fossa or the deepest region of the occlusal surface, enabling the doctor to identify and access all canal orifices [15]. The truss endodontic access cavity design employs direct access from the occlusal surface to each canal orifice while preserving a dentin bridge between the canal orifices [16]. Furthermore, novel conservative methodologies for access cavity preparations have been established, as there are instances where the tooth possesses existing restorations or exhibits carious patterns that preclude traditional or conservative access cavity preparation. A recent study demonstrated that a truss endodontic access cavity enhances the fracture strength of endodontically treated teeth in comparison to other conservative endodontic cavity designs and conventional endodontic access cavity designs [16].

The literature presents treatment options for the restoration of endodontically treated teeth, including post-core and complete or partial crowns, while advancements in adhesive technologies enable the development of conservative and aesthetically appealing dental restorations using solely composite resin materials [17]. A retrospective investigation indicated that the 5-year survival rate for severely compromised endodontically treated molars restored with composite resin was 18%, whereas the cumulative survival rate rose to 78% when the maximal quantity of dental tissue was preserved [20]. For endodontically treated posterior teeth with conservative endodontic cavity designs, the optimal access restoration is a direct restoration with a resin composite, owing to its superior binding strength to the dental substrate [20]. The evaluation of fracture resistance in endodontically treated maxillary premolar teeth following the restoration of two-walled access cavity preparations with direct composite, indirect composite, and CAD/CAM ceramic inlays revealed that composite resins exhibit the greatest fracture resistance [21]. To enhance the durability of direct composite resin restorations, glass fiber may be incorporated horizontally into the coronal structure, or fiber-reinforced resin composites can be employed to augment the fracture resistance of the core structure owing to their advantageous physical features [22]. The incorporation of glass fibers in access cavity restoration improves the flexural characteristics of composite resin, facilitating effective force transmission and enhancing fracture resistance [23]. EverX Posterior has been launched as a dentine replacement material, incorporating E-glass fibers in its formulation [24]. The manufacturer asserts that employing EverX Posterior (GC, Tokyo, Japan) in stress-bearing regions allows the restoration to demonstrate dentin-like stress management, hence inhibiting the advancement of existing fissures [25]. The advanced manufacturing of this specialized composite component has enabled us to provide great fracture resistance in composite restorations, especially in extensive posterior cavities [25]. The recent emergence of bulk-fill resin composites has garnered interest due to their translucency, which facilitates enhanced conversion rates and effective polymerization at thicknesses of 4–5 mm [26]. An elevated conversion rate enhances the material's mechanical properties, facilitating its application in load-bearing regions, particularly in post-endodontic restorations [26].

The swift advancement of materials and methods renders the identification of the optimal methodology a complex decision-making process. Current literature recommends direct resin composites for the restoration of teeth that have had root canal therapy, owing to their ability to preserve more hard tooth tissue, aesthetic appeal, adequate mechanical strength, and intracoronal reinforcement [27]. The principle of minimally invasive direct restorations is to preserve maximal tooth structure, guaranteeing a resilient bonded restoration that permits future alternatives in the event of failure. Furthermore, given the established significance of coronal seal in the literature, to mitigate coronal microleakage, the definitive restoration should commence promptly following root canal therapy, ideally at the same appointment as the endodontic procedure [27]. Postponing

definitive restoration and maintaining a root canal treated tooth with provisional restorations heightens the likelihood of periapical recontamination and subsequent failure. Kashi et al. conducted a meta-analysis to assess the survival rates of direct and indirect restorations for root canal-treated teeth, finding no significant difference between the two methods of restorations. Consequently, our samples were rehabilitated using efficient and economical direct composite materials to examine the effects of coronal restoration in conservative endodontic cavities [28].
Etching of dental hard tissue is conducted to improve surface roughness by dissolving hydroxyapatite minerals, removing smear plugs from dentinal tubules, and facilitating optimal adhesive bonding. Furthermore, whereas phosphoric acid etching seeks to facilitate adhesive dispersion by destroying enamel rods, the resultant thick, HAp-free hybrid layer on dentin is particularly vulnerable to degradation over time [29]. Self-etch adhesives with acidic monomers dissolve the smear layer and the underlying dentin structure, eliminating the need for a separate acid treatment. Besides their user-friendliness, they diminish post-operative discomfort while maintaining bond strength, owing to their propensity to induce superficial demineralization of dentin and partial blockage of the dentinal tubules within the smear layer [30]. Retreating the dentin surface with a deproteinizing agent, such as sodium hypochlorite (NaOCl), hypochlorous acid (HOCl), or papain solution, may be employed with self-etch adhesives as an innovative method to improve resin/dentin hybridization [29].
The coronal restoration of endodontically treated teeth with an elevated fracture risk is particularly demanding. Maxillary second premolars and mandibular molars that have undergone endodontic treatment are the most frequently fragmented teeth during normal mastication. Simulating the physiological environment in clinical practice is essential for in vitro investigations of dental materials. The thermal cycle is a commonly employed method for simulating the aging of restorative materials [30].

Minimally invasive endodontics prioritizes the least excision of tissue and the conservation of intact hard tooth structures across all stages, from access cavity preparation to root canal instrumentation. Minimally invasive cavity preparation seeks to preserve peri-cervical dentin and partially deroof root canal-treated teeth. The quantity of peri-cervical dentin serves as a stress distributor and is essential for the transmission of occlusal load to the radicular section of the tooth. A study utilizing finite element analysis revealed that the architecture of access cavity preparation significantly impacts the strength of endodontically treated teeth [31]. Notwithstanding advancements in material science and the notion of minimally invasive procedures, all groups with minimally invasive access cavities in our investigation exhibited significantly lower fracture strengths than undamaged teeth, regardless of the material employed ($p < 0.05$). The incorporation of reinforcing materials in the construction may be beneficial for enhancing tooth strength [31].
Current literature recommends fiber-reinforced resin composite materials for endodontically treated teeth. Mangoush et al. indicated that fiber-reinforced resin composite restorative materials were superior in fortifying structurally compromised teeth and enhancing fracture strength compared to non-fiber-reinforced resin composite restorative materials [30]. EverX Posterior is a light-cured, fiber-reinforced composite utilized as a dentine replacement material [31]. The short fibers in the structure mimic the effects of collagens in dentin, while the amalgamation of the dimethacrylate resin matrix and polymethacrylate chains, referred to as semi-interpenetrating networks (semi-IPN), renders the structure fibrous. The short E-glass fibers within the material's structure are arranged in many directions, allowing the composite to demonstrate anisotropic behavior when subjected to chewing pressures. The use of material beneath the standard resin

composite repair within the pulp chamber enhances stress absorption and improves the toughness of the restoration. Moreover, EverX Posterior's millimeter-scale short fibers inhibit crack propagation, hence reducing the detrimental effects of internal fissures within the structure and ensuring a lower incidence of catastrophic fractures [31].

Conclusion:

Recent improvements in technology and instrumentation, including as 3D imaging, operating microscopes, enhanced lighting, slender ultrasonic tips, irrigant activation, and flexible instruments, enhance the efficacy of minimally invasive endodontic procedures. The quality of photo-polymerization in this investigation was contingent upon the material used and was unaffected by variations in access cavity design; specifically, the existence of a dentinal "bridge" in the TREC cavity design did not negatively impact the degree of conversion of resin-based composites. In contrast to TEC, minimally invasive TREC correlated with heightened porosity of the high-viscosity fiber-reinforced composite everX Posterior. Glass-ionomer (Fuji IX) and nanofilled composite Filtek Supreme demonstrated superior flexibility and comparable porosity, regardless of access cavity design. The TREC design, along with non-cuspal coverage direct restoration, yielded markedly greater fracture resistance in repaired molars, although also led to a higher incidence of unrestorable fractures compared to the TEC design with cuspal coverage direct restoration. Fiber-reinforced composite everX Posterior utilized as a base beneath a nanofilled composite (Filtek Supreme) enhanced the fracture resistance of molars with TEC, whereas standard glass-ionomer Fuji IX augmented the fracture resistance of molars with TREC. Thermocycling typically reduced the fracture resistance of repaired molars, however the effect was less pronounced in minimally invasive TREC. Based on the comprehensive analysis of available data, the fiber-reinforced composite everX Posterior is advisable for the restoration of molars with a TEC cavity design, but not for those with a TREC design.

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