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Endocrown – A Major Paradigm Shift in the Restoration of Endodontically Treated Molars: A Case Report

Endokorona, zasadnicza zmiana paradygmatu w odbudowie zębów trzonowych leczonych endodontycznie: opis przypadku

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Summary

Throughout the evolution of dentistry, achieving the ideal restoration for an endodontically treated tooth has been a subject of extensive discussion and controversy. One of the primary challenges faced by clinicians is the coronal rehabilitation of such teeth, which requires balancing considerations for minimally invasive preparation, retention, and restoration stability.

Advancements in adhesive systems have significantly reduced the need for intraradicular anchorage and, consequently, the reliance on post-core systems. The endocrown emerges as a viable restorative option for endodontically treated teeth, providing an effective alternative to traditional post-core restorations and full-coverage restorations. This innovative approach enhances the stability and retention of indirect restorations without necessitating the use of a cast metal core or reconstruction with intracanal posts, thereby streamlining treatment timelines. As a result, the endocrown has gained prominence as a promising solution for the esthetic and

Streszczenie

Na przestrzeni ewolucji stomatologii osiągnięcie idealnej odbudowy zęba leczonego endodontycznie było przedmiotem rozległych dyskusji i kontrowersji. Jednym z głównych wyzwań stojących przed klinicystami jest rehabilitacja koronowa takich zębów, która wymaga równoważenia czynników minimalnie inwazyjnej preparacji, retencji i stabilności odbudowy.

Postęp w systemach adhezyjnych znacznie zmniejszył potrzebę zakotwiczenia wewnątrzkorzeniowego, a w konsekwencji konieczność stosowania systemów wszczepialnych. Endokorona okazuje się realną opcją odbudowy zębów leczonych endodontycznie, stanowiąc skuteczną alternatywę dla tradycyjnych uzupełnień typu post-core i całkowitych koron. To innowacyjne podejście zwiększa stabilność i trwałość uzupełnień pośrednich bez konieczności stosowania odlewanego wkładu metalowego lub rekonstrukcji za pomocą wkładów wewnątrzkanałowych, skracając w ten sposób czas leczenia. W rezultacie endokorona zyskała na znaczeniu jako obiecujące rozwią-

functional rehabilitation of endodontically treated teeth. In this case report, a severely damaged mandibular molar was successfully restored using an all-ceramic endocrown, which served as a conservative and esthetic alternative to a full-coverage crown.

zanie w estetycznej i funkcjonalnej rehabilitacji zębów leczonych endodontycznie. W tym opisie przypadku znacznie uszkodzony ząb trzonowy w żuchwie został pomyślnie odbudowany przy użyciu endokorony pełnoceramicznej, co stanowiło zachowawczą i estetyczną alternatywę dla korony całkowitej.

Introduction

In dental practice, dentists frequently encounter endodontically treated teeth that require restoration due to significant damage. The restorative therapies employed must preserve the remaining tooth structure while restoring the tooth's aesthetics, form and function effectively.

Over the past few decades, patients' expectations have shifted, placing a strong emphasis on aesthetics, not only in the anterior region but also for the posterior teeth restorations. In the past, the conventional approach involved creating a peripheral crown, with or without a root post, to reinforce a tooth which is pulpless and with substantial tissue loss.[1]

However, current trends favour a more conservative and less invasive approach. Intentional mutilation of teeth to accommodate a restoration is no longer acceptable. Instead, the focus is on adapting the restoration technique to the existing residual tissue.

In 1995, Pissis introduced the concept of one-piece preset glass-ceramic crowns, known as endocrowns, which utilize the pulp chamber to enhance macromechanical retention. Endocrowns have emerged as a viable solution for restoring endodontically treated teeth with a unitary prosthetic rehabilitation approach.[2]

By utilizing the pulp chamber, endocrowns increase the bonding surface area and retention, ensuring a stable and reliable restoration. The objective of this case report is to explore the current literature on endocrowns, evaluating their effectiveness and reliability in restoring pulpless teeth, and identifying scenarios where endocrowns are the restoration of choice.

Case report

A healthy 53-year-old patient was referred to the Fixed Prosthodontics

Department at the dental clinic to restore her molar tooth (37). The medical history was noncontributory.

Radiographic and clinical examinations were performed initially and a provisional restoration of a nonvital molar tooth (37) was identified with completed satisfactory endodontic treatment.

The patient presented acceptable oral hygiene and a favourable occlusion.

The prosthetic decision was made to restore tooth (37) with an endocrown fabricated from lithium disilicate ceramic (IPS e.Max CAD).

Fig. 1. Initial case.

Fig. 2. Peripheral and intra-coronal tooth preparation.

Preparation

In this clinical situation, the condition of the residual walls suggested a butt margin preparation. The goal of this preparation is to achieve an overall reduction in the height of the occlusal surface of at least 2 mm in the axial direction. To accomplish this, a turbine-mounted diamond bur was utilized, which was oriented along the main axis of the tooth and kept parallel to the occlusal plane, enabling precise control of the reduction and the creation of a smooth, flat surface. Ideally, the margins should be kept supragingival all over.

The preparation procedure involved eliminating undercuts in the access cavity using a cylindro-conical green diamond bur. The bur was oriented along the longitudinal axis of the tooth to ensure a continuous and harmonized preparation. It is essential to avoid removing excessive tissue from the inner walls of the pulp chamber to maintain the thickness of both the walls and enamel band required for good bonding. Large cameral undercuts are filled with a composite resin or glass ionomer cement that is modified with resin for superior mechanical properties. Tissue preservation is always considered during the procedure. For greater retention, the cavity floor can be prepared by clearing the canal entrances. In this clinical case, the pulp chamber was deemed to be of sufficient height (5 mm), and penetration of the root canal orifices was unnecessary.

Impression procedure

A one-phase impression was taken with putty and light body polyvinyl siloxane material and sent to the laboratory. Developments have opened up a whole new world of recording possibilities, and it is now possible to make an optical impression.

Temporization

An temporary endocrown made with self-curing resin. The cementation was made using

Fig. 3. One-phase impression.

a temporary cement without eugenol (Temp Bond NETM)

Computer-aided design

The impression was sent to the prosthetic laboratory where the technician cast and scanned the models. The working model, antagonist model, and confronted models were scanned to record the patient's occlusion. Then, the technician carried out computer-aided design using Sirona's Cerec in Lab® CAD/CAM system.

Fig. 4. Data acquisition.

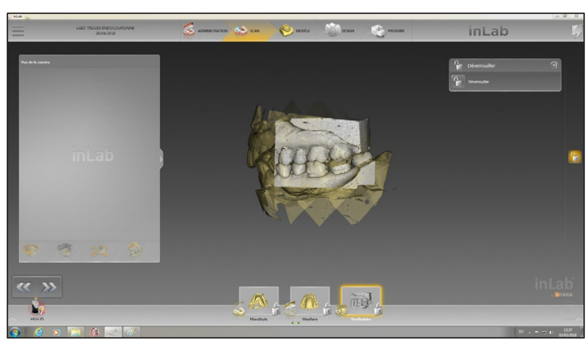

Fig. 5. PIM scanning of models.

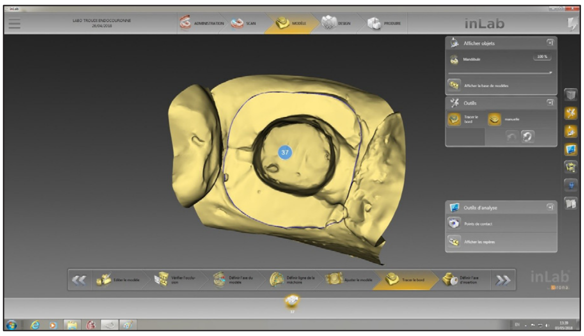

Fig. 6. Limit visualization.

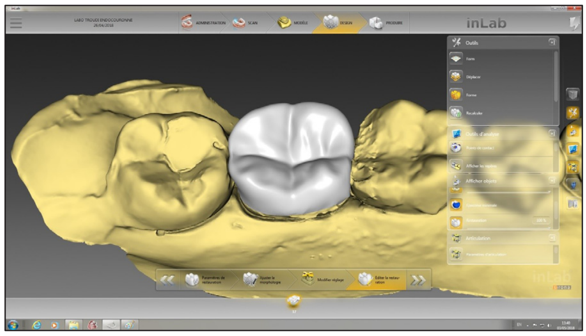

Fig. 7. Endocrown design.

Computer-aided manufacturing:

Endocrown restorations can be milled with CAD/CAM technology (Computer-aided Design/Computer-aided Manufacture), which minimizes clinical adjustment procedures and the incorporation of defects during preparation, as well as allowing the treatment to be performed in a single session. The CAD-CAM system has a biogeneric option, which is a data base that selects occlusal anatomy that better adapts to the scanned preparation and antagonist anatomy, thereby eliminating the need for diagnostic waxing.

Try-in protocol

The endocrown was tried in the mouth (in a biscuit bake state) after removing the provisional restoration. The marginal fit, shade, shape were evaluated. The static occlusion was controlled after cementation.

Fig. 8. Fabricated endocrown on cast.

Fig. 9. Endocrown.

Bonding

The selection of an adhesive for a bonded partial restoration is a critical decision that requires careful consideration by the clinician. With the wide variety of bonding systems available, choosing the appropriate system has become increasingly challenging. Regardless of the chosen system, it is crucial to apply the bonding protocol rigorously and adhere to the manufacturer's guidelines. For the endocrown, an adhesive without adhesive potential and with dual setting is the preferred system due to the significant thickness of the restoration. The composite resin used is "microfilled" or "microhybrid"," which is similar in composition to restorative composites but with a higher proportion of resin and lower viscosity, enabling easier and more precise application to the bonded element. These composites do not contain adhesion promoters and are used in conjunction with an amelo-dentinal adhesive system to infiltrate the roughness of the previously etched dental surfaces, creating a mechanical keyway. The adhesives form a bond between the adhesive layer (or hybrid layer) and the prosthetic element, using a coupling agent or silane to impregnate the surface of the intrados. The bonding protocol for the endocrown involves three steps.

Preparation of the inner surface of the endocrown

The first step of cementing the endocrown is the proper preparation of its inner surface

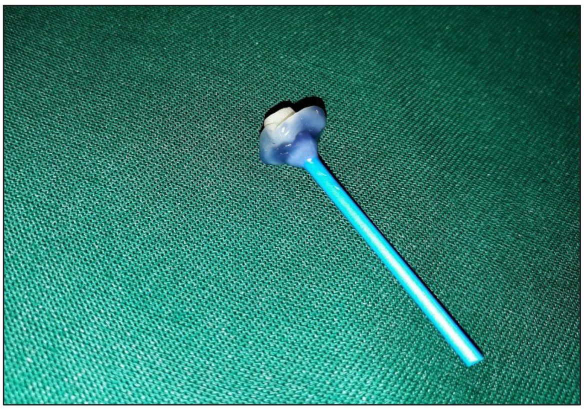

Fig. 10. Protecting the extrados of the endocrown.

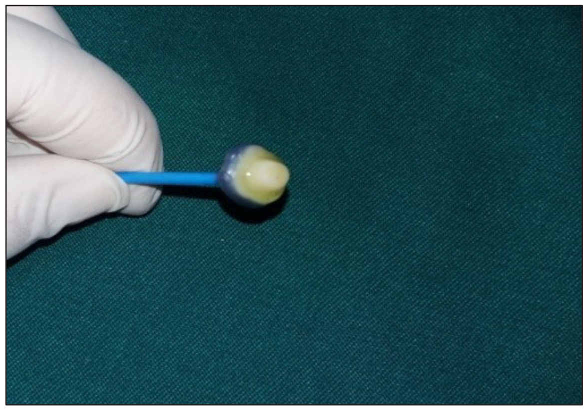

Fig. 11. Etching the endocrown with hydrofluoric acid.

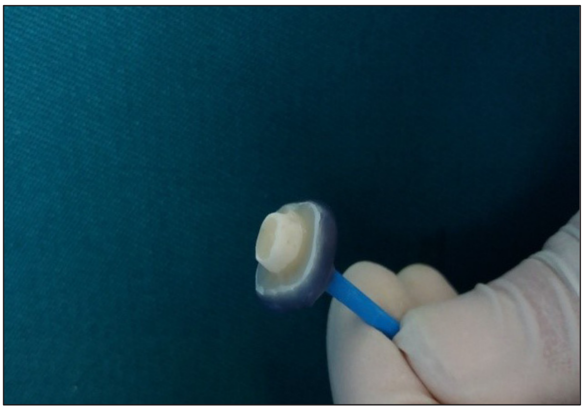

Fig. 12. Chalky white aspect.

Fig. 13. Application of silane coupling agent.

using 5 to 10% hydrofluoric acid for twenty seconds, which should dissolve the glass matrix to expose the crystalline structure and create surface microrugosities. Prior to etching, the extrados must be protected with blue wax. Once etching is complete, the surface is thoroughly rinsed and dried until a chalky white appearance is obtained. Next, a coupling agent, such as silane, is applied, typically pre-hydrolyzed to facilitate immediate use to bind the organic with the inorganic ones, to create a chemical bond between the composite resins and the inorganic glass matrices. The intrados is then left in the open air for at least three minutes or heated for approximately one minute using a light curing lamp or other heat-generating device to optimize the polycondensation of the silanol and enhance its effectiveness for further bonding.

Preparation of dental surfaces

Effective bonding requires thorough preparation cleaning. This can be achieved using ultrasound or fluoride-free paste. The tooth surface is then treated with 37% orthophosphoric acid, with enamel

Fig. 14. Acid-etching the tooth.


Fig. 15. Application of the bonding agent.

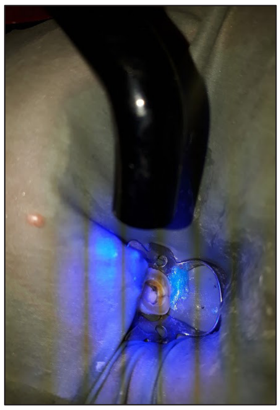
Fig.16. Light-curing the bonding agent.


Fig. 17. Application of the bonding resin.

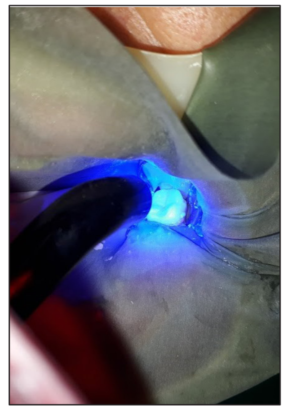
Fig. 18. Final cementation.

receiving 30 seconds and dentine 15 seconds of application time. After this, the surface is rinsed for at least the same amount of time as the application time and then dried moderately. The adhesive is then repeatedly applied to the dentine using a Microbrush for 20-30s. Finally, a gentle blast of air is used to prevent product build-up in the cavity. In this case, the adhesive is light-cured.

Cementation

A thin layer of a dual polymerizing resin was applied to the prosthetic endocrown and then inserted into the tooth and polymerized at intervals of 5 seconds, making it easy to remove cement excesses. After that, it was polymerized for 60 seconds on all surfaces. The restoration was examined for any occlusal interference using ceramic finishing instruments.

Discussion

The restoration of endodontically treated teeth is a crucial aspect of dental practice, aiming to restore the anatomical, functional, and aesthetic integrity of teeth following root canal therapy. This process involves meticulous consideration of various factors, including material selection, techniques and approaches.

Preserving the remaining tooth structure is of paramount importance in the restoration


Fig. 19. Occlusal view of cemented endocrown.


Fig. 20. The final result.

of endodontically treated teeth. Whenever feasible, a conservative approach is adopted to retain as much healthy tooth structure as possible. This involves the meticulous removal of any remaining caries or compromised dental tissue, followed by the preparation of the tooth to accommodate the restoration.[3]

Numerous restorative strategies have been proposed for teeth that have undergone root canal therapy, offering a spectrum of treatment choices based on their level of invasiveness. These options encompass both direct and indirect restorations.

Indeed, ETT are brittle and prone to fractures due to the loss of structural integrity associated with the access cavity, which leads to an increase in the cavity depth and cuspal flexure. Their biomechanical deterioration impacts the tooth's long-term prognosis.[4]

Accordingly, in general they necessitate cuspal coverage due to their unique shape and the increased chewing forces they endure. When a significant portion of the tooth's crown is lost, a core build-up and crown become essential for restoration. However, if there is insufficient natural tooth structure tissue remaining to support the core, an additional retentive method is required.

Traditionally, posts or dowels were employed to anchor the core in such situations. Initially, it was believed that the post and core reinforced the remaining tooth structure, but subsequent studies revealed that their primary role is to enhance the retention of the restoration. Nevertheless, the insertion of a post could weaken the root and increase the risk of fractures, potentially complicating future endodontic re-treatment if necessary.[5] Turner conducted a study involving 100 instances of post-retained crown failures and highlighted that the predominant type of failure was the loosening of the post. Out of the 100 failures, 59 were attributed to post loosening. The subsequent prevalent occurrences were apical lesions and caries, followed by crowns that were either fractured or became loose. Among these cases, there were 10 instances of fractured roots and 6 cases of fractured posts.[6]

The introduction of effective dentine bonding agents brought about a transformation in the restoration of endodontically treated teeth. As long as enough surface area is available for micro-mechanical retention, the need for radicular posts decreased in popularity. Subsequently, in 1999, *Bindle* and *Mörmann* introduced the Endocrown technique, an adhesive restoration with minimal preparation that offers ample retention, stability and structural durability to the restoration. This approach emerged as a promising alternative to traditional post and core restorations. They are particularly suitable for teeth with short or atresic clinical crowns, calcified or curved root canals that make post application impossible.[7]

Since mandibular molars are subjected to more significant masticatory forces and unfavourable stresses, the higher compressive strength and lower stress levels exerted on the tooth make endocrown restorations a suitable and favourable choice in this particular case.[8]

Furthermore, a systematic review conducted by *Sedrez-Porto* et al. evaluated both clinical (survival) and *in vitro* (fracture-strength) studies of endocrown restorations in comparison with conventional treatments involving intraradicular posts, direct composite resin or inlay/onlay restorations. The findings indicated that endocrowns performed similarly well, or even better than conventional treatments.[9]

Based on the results of a systematic review with meta-analysis, it has been demonstrated that endocrown restorations exhibit superior fracture strength compared to conventional restorations. Several factors contribute to this positive outcome, including differences in configuration, design, thickness, and elastic moduli.[10]

Traditionally, a ferrule is used as a bracing mechanism to retain the restoration around the cervical tooth structure in conventional restorations. However, the presence of a ferrule can lead to the loss of sound enamel and dentine tissues, which are crucial for proper bonding of the restoration. In contrast, endocrowns are typically prepared without a ferrule, offering better preservation of dental tissues.[11]

A study by *Nagasiri* and *Chitmongkolsuk* study demonstrated that a greater amount of remaining tooth structure was associated with increased longevity of the tooth.[12] Undeniably, conservative bonded options, like endocrowns, offer several advantages including preservation of dental and periodontal tissues, reinforcement of healthy residual dental tissues, and aesthetic, ergonomic and economic benefits. The concept of endocrowns has become an attractive option for the restorative treatment of molars with extensive coronal destruction. However, careful planning is necessary to ensure efficient treatment and long-term clinical success.

Additionally, endocrowns have a greater occlusal thickness ranging from 3 to 7 mm compared to the 1.5 to 2 mm thickness of conventional crowns. This increased thickness contributes to higher fracture resistance and the ability to withstand occlusal loading.[13]

Studies conducted by *Biacchi* and *Basting*, as well as *Chang* et al., showed that endocrowns exhibited higher fracture strength compared to restorations using glass fiber posts. The occlusal thickness of the restoration is a significant factor influencing fracture resistance.[14,15]

Another factor that differentiates endocrowns from conventional restorations is the choice of materials. Conventional restorations often utilize materials with different elastic moduli, such as metals or glass-reinforced fibers for the post portion, and resin composites or ceramics for the core/crown portion. This stiffness mismatch between the restorative materials and the tooth structure can contribute to restoration failure. In contrast, endocrowns have a more uniform elastic modulus, resulting in better stress distribution and improved biomechanical activity.[16,17]

In light of this, it has been scientifically reported that endocrowns exhibit/have a high success rate, ranging from 94% to 100%.[18] These restorations are regarded as a conservative and viable treatment alternative for teeth that have undergone endodontic procedures.[19,20] After approximately five years, the success rate of endocrowns was found to be 77.7% compared to 94% for conventional crowns. Furthermore, endocrowns exhibited a five-year survival rate of 91.4% in contrast to 98.3% for conventional crowns.[21] Clinical and *in vitro* studies consistently report excellent survival rates and satisfactory clinical performance of endocrowns for molars short, medium, and long term. Endocrowns also demonstrate fewer catastrophic failures compared to conventional crowns, with only 6% of root fractures compared to 29% for crowns. The primary cause of failure in endocrowns is usually loosening (71%).[22]

The high clinical success rate of endocrowns can be attributed to several key factors, including meticulous preparation techniques, the judicious selection of appropriate materials, and the precise execution of cementation procedures.

The primary objective of tooth preparation for endocrowns is to establish a wide and stable surface capable of effectively resisting the frequent compressive stresses experienced in molars.[23] This is achieved by preparing the surface in parallel alignment with the occlusal plane, thereby providing enhanced stress resistance along the major axis of the tooth.[24] Notably, teeth restored with endocrowns exhibit lower stress levels compared to those restored with prosthetic crowns.[25,26]

The advancement of adhesive cementation systems has led to a decreased need for macro retentive preparations in crown restorations.[27] Additionally, the pulpal chamber cavity contributes to retention and stability of the endocrown restoration, with its trapezoidal shape in mandibular molars providing increased stability, thereby eliminating the necessity for additional preparation.[24] Moreover, the saddle form of the pulpal floor, coupled with the adhesive qualities of the bonding material, renders the use of post-involving root canals unnecessary as it results in a decrease in the marginal and internal adaptation of the endocrowns and the clinical performance of the restorations.[28] Consequently, the root canals do not require specific shaping, and they remain resilient, avoiding the stresses associated with post usage.[29] As a result, compressive stresses are effectively distributed over the cervical butt joint and the walls of the pulp chamber.[30-32]

In 2018, *Dartora* et al. conducted a biomechanical evaluation of endodontically treated teeth restored using different extensions of endocrowns within the pulp chamber. Their study revealed that greater extension of endocrowns resulted in improved mechanical performance. Specifically, a 5 mm extension exhibited lower intensity and a more favourable stress distribution pattern compared to a 1 mm extension, which displayed reduced fracture resistance and an increased risk of rotation during function.[33] Likewise, *Dietschi* and **Spreafico** (1997) proposed an optimal range concerning the height of the pulp chamber, advocating for its positioning within the span of 3 to 5 mm. This strategic positioning serves to optimize the potential bonding surface area, thereby effectively mitigating the probabilities of material displacement.[34] Similarly, *Lin* et al. (2010) recommended a minimum depth falling within the range of 4 to 5 mm.[35] Furthermore, *E. D'incau* et al. (2011) emphasized the importance of incorporating a residual coronal height of 1 to 1.5 mm above the gingival level to complement the retention parameter for effective outcomes.[36]

In an *in vitro* study conducted by *Taha* et al., the effect of varying margin designs on the fracture resistance of endodontically treated teeth restored with polymer-infiltrated ceramic endocrowns was assessed. The results indicated that endocrowns with axial reduction and a shoulder finish line exhibited higher mean fracture resistance values than those with a butt margin design. This observation underscored the stabilizing effect of butt joint designs, which resist compressive stresses due to their preparation parallel to the occlusal plane.[37]

The butt margin design distinguishes itself through its notable capacity to uphold the integrity of tooth structure while also exhibiting enhanced operational efficiency and reduced susceptibility to technique-associated sensitivities when contrasted with the shoulder margin design.[38]

Nonetheless, according to *Fages* et al., from a biomechanical perspective, the endocrown restoration accommodates strains at the bonded joint, with forces evenly distributed over the cervical butt joint (compression) or axial walls (shear force). The inclusion of short axial walls with a shoulder finish line may counteract shear stresses through the walls, leading to improved load distribution through the margin and, in turn, moderating the load on the pulpal floor.[24] Additionally, axial reduction may reduce the resin cement thickness in relation to the bulk of ceramic material, thereby minimizing thermal and polymerization shrinkage and decreasing stress applied to the ceramic.[39]

Regarding the choice of materials used, ideally, an endocrown should be fabricated from a material with a low modulus of elasticity similar to that of the tooth structure, high mechanical strength, and sufficient bond strength to the underlying tooth structure. A modulus of elasticity comparable to dentine helps distribute occlusal forces along the bonded surface and improves fracture resistance. High mechanical strength is important for withstanding occlusal load and resisting material fracture.

In this case report, the material of choice for endocrowns is glass-ceramic reinforced with lithium disilicate due to its exceptional bonding properties, optical characteristics and mechanical strength. The fabrication of endocrowns can be accomplished using either pressing techniques or Computer-Aided Design and Manufacturing (CAD/CAM) methods.[20,40]

Altier et al. conducted a comparative study assessing the fracture resistance of endocrowns made from lithium disilicate ceramic and indirect resin composite. It was concluded that lithium disilicate ceramic endocrowns exhibited higher fracture strength compared to indirect composites.[41] However, a recent study by *Tribst* et al. suggested that leucite-reinforced glass-ceramics could offer better stress distribution and serve as a reliable alternative to lithium disilicate for endocrown fabrication.[42]

In an *in vitro* study on mandibular molars, the fracture strength of lithium disilicate-reinforced ceramic endocrowns was compared to glass fiber post-supported conventional crowns. The study showed that endocrowns displayed higher fracture strength, suggesting that reinforced ceramics should be the material of choice for endocrown fabrication.

Gresnigt et al. conducted an *in vitro* study comparing the fracture strength of $Li_2Si_2O_5$ (lithium disilicate) and multiphase resin composite used as endocrown materials. The results demonstrated similar fracture strength under axial loading, but the multi-phase resin composite exhibited significantly lower results under lateral forces.[20]

El Damanhoury et al. showed that resin nanoceramic (RNC) endocrowns had significantly better fracture resistance than lithium disilicate-reinforced ceramic endocrowns. The high fracture strength of RNC endocrowns can be attributed to their unique composition comprising 80% nanoceramic particles and 20% resin matrix. Conversely, under lateral loading, lithium disilicate-reinforced ceramic endocrowns displayed superior fracture resistance compared to RNC endocrowns, primarily due to their excellent micromechanical interlocking with the resin cement and adhesion between the tooth surface and resin cement.[43]

A recent study by *Zoidis* et al. proposed the use of polyetheretherketone (PEEK) for endocrown fabrication. This study revealed that the elastic moduli of PEEK, along with indirect composite resin, provided better support to the tooth structure compared to ceramics. However, further long-term clinical trials are necessary to validate this approach.[44]

Nanofill composite resins offer intriguing characteristics for endocrown fabrication thanks to their modulus of elasticity, akin to that of dentine, thereby limiting irreparable fractures while retaining high fracture resistance. However, a decrease in elastic modulus may reduce stress in the dentine while increasing it at the interface, thus leading to risks of debonding of the prosthesis.[45] In addition, the fracture resistance observed for the different materials considered was mainly greater than the masticatory forces. As the risk of debonding has been shown to be greater than the risk of fracture, materials with the greatest adhesion values, such as lithium disilicate, are the best choice. Furthermore, the aesthetic properties of this material are unrivaled by composite resin, which can be an advantage for some patients. Ceramics also age better and have a lower plaque retention than composite resins.[46]

Additionally, *Skalskyi* et al. conducted a comparative study evaluating the fracture resistance of different restorative materials employed in dental endocrown restorations. Zirconium dioxide endocrowns were found to exhibit crack propagation in the tooth, whereas metal ceramic endocrowns demonstrated the lowest risk of failure during clinical use, and displayed the highest fracture strength.[47]

Conclusion

The utilization of endocrowns presents a viable substitute for the conventional approaches involving post and core applications particularly in the rehabilitation of teeth that have undergone endodontic treatment and exhibit significant loss of coronal tissue. This restorative technique finds its principal applicability within posterior teeth, demonstrating notably enhanced efficacy within molars compared to premolars.

Endocrowns offer several distinct merits. These encompass heightened aesthetic outcomes, mechanical performance, conservation of remaining tooth structure, low cost and short clinical time. Furthermore, their utility extends to the successful restoration of teeth characterized by limited clinical crown dimensions.

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