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Review / Derleme

Restorations of Endodontically Treated Teeth: Endocrowns

Endodontik Tedavili Dişlerde Restorasyonlar: Endokronlar

Şevval Sena AK Korkut[α](ORCID-0000-0002-8608-2873), **Zühre Hale CİMİLLİ**[β](ORCID-0000-0001-7775-2145)

[α]İstanbul University, Faculty of Dentistry, Department of Endodontics, İstanbul, Türkiye
[α]İstanbul Üniversitesi, Diş Hekimliği Fakültesi, Endodonti AD, İstanbul, Türkiye
[β]Marmara University, Faculty of Dentistry, Department of Endodontics, İstanbul, Türkiye
[β]Marmara Üniversitesi, Diş Hekimliği Fakültesi, Endodonti AD, İstanbul, Türkiye

ABSTRACT

Endodontically treated teeth (ETT) are fragile compared to vital teeth. The reason for the decrease in fracture resistance and hardness is related to the deterioration of the structural integrity as a result of caries, trauma and cavity preparation. Restorations in endodontically treated teeth are applied considering the remaining tooth structure and functional status. For many years, post core systems that require additional preparation in the root canal, as well as the loss of most of the coronal tooth structures, are used for the final restoration of endodontically treated teeth. Endocrowns are monoblock restorations that attach to the pulp chamber and its walls, providing macro-mechanical and cementation with micro-mechanics, thus requiring no additional preparation. The first study written on ceramic endocrown was published in 1995. In this study, it is defined as a ceramic monoblock production technique for the restoration of endodontically treated teeth. This procedure was later named "endocrown" in 1999.

Keywords: Endodontics, Dental restoration, Ceramics.

ÖZET

Endodontik tedavi görmüş dişler vital dişlere göre daha kırılgandır. Kırılma direnci ve sertliğindeki azalma, çürük, travma ve kavite preparasyonuna bağlı olarak yapısal bütünlüğün bozulması ile ilişkilidir. Endodontik tedavi görmüş dişlere restorasyon uygulanmadan önce kalan diş yapısı ve fonksiyonel durum göz önünde bulundurulur. Uzun yıllardır endodontik tedavi görmüş dişler, ek kök kanal hazırlığı ve koronal diş yapılarının çoğunun çıkarılmasını gerektiren post-kor sistemleriyle restore edilmiştir. Endokronlar, pulpa odasına ve duvarlarına bağlanan, makromekanik ve mikromekanik destek sağlayan, dolayısıyla ek bir hazırlık gerektirmeyen monoblok restorasyonlardır. Seramik endokron üzerine yazılan ilk çalışma 1995 yılında yayınlanmıştır. Bu çalışmada endokronlar, endodontik tedavi görmüş dişlerin restorasyonu için seramik monoblok üretim tekniği olarak tanımlanmıştır. Bu prosedür daha sonra 1999'da "endokron" olarak adlandırılmıştır.

Anahtar Kelimeler: Endodonti, Dental restorasyon, Seramik.

INTRODUCTION

A tooth with a root canal treatment indication has experienced an excessive loss of tooth tissue due to caries and trauma. In addition, the tooth's structural integrity is disrupted due to cavity preparation, mechanical instrumentation required during endodontic treatment, and mechanical force applied in obturation ([1]). As a result, there is an increased risk of fracture in endodontically treated teeth (ETT), which are more biomechanically weakened than vital ones. Structural changes such as water loss in dentin tissue, collagen degradation, and intermolecular cross-linking of root dentin were also observed in devital teeth ([2]). The restoration of ETT is aimed at restoring the loss of tooth tissue, preventing recontamination of the root canal system, restoring morphology and function, designing the restoration to resist functional stresses, and preventing crown/root fractures ([3]). The gold standard for restoring ETT with successful clinical longevity requires minimal invasive preparations and maximal tissue conservation ([4]). In a study, ETT were followed for eight years. It was observed that 85% of the teeth resulting in extraction due to the permanent restoration could not complete the tooth tissue in a way that would not prevent microleakage ([5]). It has been concluded that eliminating factors such as microleakage with a restoration makes endodontic treatment successful in the long term by preventing contamination ([6]). Correct selection of the restoration material is necessary to ensure the integrity of the tooth structure. The health of periodontal tissues, alveolar bone support, crown/root ratio, and, most importantly, coronal loss is considered in the restoration and treatment plan of ETT. Restoration preferences for anterior or posterior teeth vary depending on the force encountered. Patient-related conditions such as age, systemic, and socioeconomic status should be evaluated. Amalgam restorations, direct and indirect composite restorations, inlay and onlay restorations, post-core systems, and metal-ceramic, all-ceramic crowns and endocrowns are restoration options for ETT. In 1999, Bindl and Mormann described the endocrown for the first time as an adhesive endodontic crown used as a viable alternative treatment modality to conventional post/core and crown with the advancement of adhesive dentistry ([4]). This approach results in minimal tooth structure loss, superior mechanical properties, fewer clinical steps, and reduced cost ([7]).

MULTIDISCIPLINARY PERSPECTIVE

Mostly, endodontic treatment is indicated as a result of caries reaching the pulp. However, endodontic treatment may be required in cases where non-carious lesions such as abrasion, erosion, or abfraction occur, and pulp exposures encountered with or without iatrogenic causes during the preparation of fixed prosthetic restorations. Endodontic and restorative treatment should be planned from all perspectives. It is necessary to determine the current health condition of the patient with the anamnesis and clinical examination. It has been observed that the adequacy of the supporting periodontal tissue in ETT is effective in the long-term prognosis of the tooth. In a study, it was observed that ETT in patients with mild and moderate periodontitis resulted in more extraction than ETT in patients with healthy periodontium ([8]). In the light of these studies, it is important to question conditions such as excessive consumption of the chemical, erosive foods in the diet, and the presence of bad habits, depending on the patient, during the anamnesis and clinical examination. Older restorations should be completely removed to evaluate the instantaneous condition of the tooth and to predict its prognosis. All caries must be completely cleaned. Structural integrity can be achieved with the correct type of restoration, with the distance between the incisal/occlusal of the tooth and the alveolar crest of 3 mm to protect the biological space, and at least 2 mm to provide sufficient space for the restoration margins, a total of 5 mm. In cases where the remaining tooth tissue is less than 5 mm, orthodontic tooth extrusion or crown lengthening procedure may be considered. In addition, the crown/root ratio should be evaluated. The minimum desired crown/root ratio for

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Sorumlu yazar/Corresponding Author: Şevval Sena AK KORKUT
E-mail: sevvalsenaak@hotmail.com
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resistance to lateral forces is 1/1 ([9]). It is necessary to preserve the remaining tooth tissue as much as possible in ETT. The ferrule effect is created by the remaining parallel dentin walls surrounding the crown. In crown, restoration resistance increases with this ferrule support in the tooth ([10]). In a study, a 9-year follow-up of 400 ETT was performed. Six times more fractures were observed in ETT with restoration, including tubercles, than in restorations without tubercles ([11]). In another study, 759 ETT and 858 re-treated teeth were followed for 4 years and it was observed that there was a 50% lower risk of loss in teeth with suitable proximal contact ([12]). This can be explained by a more proportional distribution of occlusal forces in the presence of proximal contact and less axial stress on the teeth. Thus, it is important to evaluate every aspect of the treatment plan.

Restoration Options of The ETT

Restoration options in ETT can be classified as restoration options in anterior and posterior teeth and restoration options with and without a post. Anterior teeth are exposed to more lateral and shear forces, while posterior teeth are exposed to more vertical forces. In this case, the need for post applications or onlay restorations in ETT increases compared to vital teeth. In teeth without horizontal or vertical fractures, requiring little or no restoration, and where root canal treatment is indicated, the presence of cavities to reach the pulp chamber does not affect the biomechanical conditions of the tooth. In case of loss of half or less of the tooth structure, there is still sufficient tissue for the stability of the restoration. In the loss of more than half of the tooth structure, post-core restorations have been used for many years. The purpose of post applications is to regain the lost stability of restorations. Nevertheless, post core applications are contraindicated in teeth with thin root form recipient to fracture, in teeth with occluded or curvature root form, in the presence of untreatable periapical pathology, and patients with poor oral hygiene and unmotivated patients ([13]). Endocrowns can be offered as a restoration option and can be done with less material loss where posts are contraindicated.

Restorations in Endodontically Treated Anterior Teeth

Primarily, direct restorations are preferred for anterior teeth. Composite resins, crown restorations, internal whitening, and conservative porcelain veneers are restoration options for endodontically treated anterior teeth ([14]). Posts can be applied in teeth with crown indication due to excessive loss of tooth tissue such as incisal edge losses and fracture cases to provide retention and resistance ([15]).

Restorations of Endodontically Treated Posterior Teeth

Amalgam restorations, direct and indirect composite restorations, and inlay and onlay restorations are preferred for posterior teeth. The presence of more dental tissue and large pulp chambers than anterior teeth provide adequate core retention and increases the adhesion surface. Overlay restorations with covered tubercles are recommended when the risk of fracture is high, such as premolars, or in the presence of parafunctional and high functional strengths. Endocrown restorations may be preferred in cases where post applications are contraindicated.

Restorations Without Post Core Systems in ETT

All restoration options are indicated for teeth in which only the endodontic access cavity has been opened and all four walls remain intact. Numerically, for the tooth to be restored conservatively, there must be solid dentin tissue of at least 1.5 mm thick and 3-4 mm high in the buccal and lingually ([16]). Post application is not mandatory as long as tissue loss is minimal in mesioocclusal, distoocclusal, and mesial-occlusal-distal class two cavities and class three cavities covering the proximal anterior teeth ([17]). The average survival rate of complex amalgam restorations has been reported as 14.6 years ([18]). However, composite materials and dental ceramics have become alternative treatment with the developments. Composite formulations have been constantly changing since the introduction of Bis-GMA, which constitutes the basic structure of composite material, to dentistry ([19]). Studies have shown that the compressive strength of the composite material is sufficient and resistant to fractures. Their use has become widespread as they can be bonded to enamel and dentin with adhesive systems and meet aesthetic expectations. However, it was observed that the adhesive surface of the composites could not withstand the stresses due to polymerization shrinkage in high C factor cavities ([20]). Polymerization shrinkage is tried to be reduced in new generation composites ([21]). Composite restorations can be applied by indirect and direct methods. In the first use of direct composite material, fractures were observed in the posterior teeth due to insufficient resistance, and its use was preferred for anterior teeth ([21-23]). Failure to ensure proper interproximal contact and direct delivery to the deepest areas in cavity preparation may lead to failures in the application of direct composite restorations. Indirect application methods have been developed to eliminate the disadvantages of polymerization shrinkage and moisture sensitivity. In addition to the composite material, metal, polyetheretherketone and ceramic materials can also be applied by indirect methods.

Post Core Restorations in ETT

Post systems are applied if one to three walls of the intact tooth tissue remain after the cleaning of caries, the removal of the restorations, and the completion of the canal filling and if there is sufficient height and thickness. The preparation of crown restorations following post systems, leads to a decrease in tooth tissue, especially in the cervical region, and decreases its resistance to destructive forces. Thus, increasing the width of the post increases the risk of fracture of the tooth root. Perforations on the root surface are a common complication due to errors in post preparation ([24, 25]). Post systems are classified as metal, fiber, and ceramic according to the material used, parallel, angled, and parallel-angled according to their shape, active and passive according to their surface, prefabricated and cast according to the technique of making. Post length, diameter, and angle luting cement material, having an active or passive surface affect the vertical resistance of the post, while the remaining tooth tissue, the hardness of the post, and the presence of ferrule create the horizontal resistance of the post ([24-27]). The application of post on teeth to be used as a supporting tooth is fixed or removable dentures will increase the risk of failure. It should be ensured that sufficient gutta-percha or obturation material remains in the root canal after preparation to prevent the potential occurrence of endodontic disease. Spaces between the post and obturation material alongside the apical plug may lead to an increased incidence of apical disease, similar to spaces in obturation ([28-30]). In anterior teeth with ovoid canals, such as canines, the post only interacts with the lateral walls. In such cases, cast posts should be used instead of prefabricated posts in order not to lose too much tissue from the tooth. The prognosis of post applications in ETT is permanent and long-term with the provision of coronal structure, ferrule support, and successful endodontic treatment ([14]).

ENDOCROWN RESTORATIONS

Restoration options for ETT are composite or amalgam fillings, inlay and onlay restorations, and crowns with post-core systems. Endocrowns have been designed as an alternative to post-containing restorations with developing dental technologies, CAD/CAM systems, and adhesion methods. The first published work on endocrown restoration was carried out by Pissis in 1995. In this study, the ceramic monoblock technique is described for teeth with excessive loss in the coronal structure. The designation of the procedure as "endocrown" was provided by Bindl and Mörmann in 1999. The central retaining part is formed with the inner walls of the pulp chamber. Endocrown restorations are indicated in cases where calcified or dilacerate canal morphologies that cannot be applied post-core, teeth with periodontal problems such as gingival recession, furcation gap, conditions where the occlusal distance is insufficient, teeth with apical resections and crown/root ratio changed, and where adequate ferrules are not available and cannot be applied ([31-34]). In the endocrown preparation of molar teeth, it is aimed to obtain a wide, and stable surface that is resistant to the compression forces most commonly observed in molar teeth ([35]). At least 2 mm provides macromechanical and micromechanical, optimal resistance with developing adhesive systems. Smooth internal passages, flat pulpal floor with closed canal openings, 5°-7° occlusal approach angle, and supragingival enamel margins with 90° 'butt margin' preparation should be provided in endocrown preparations ([33]). Endocrowns can restore lost tubercles without the need for additional preparation in the root canal. Thus, the harmful horizontal forces applied to the root in the post-core

systems were tried to be eliminated ([36-39]). By creating an apical retention cavity, it provides the transmission of lateral forces generated during working and balancing contacts to the pulp chamber instead of the root canal. According to the preferred adhesive system, the dentin surface is etched using 35% to 37% phosphoric acid. The phosphoric acid application increases the dentin surface energy, provides removal of the smear layer, and causes demineralization of the hydroxyapatite crystal surface. Due to these factors, endocrown restorations cannot be applied in cases where adhesion conditions are not met, the pulp chamber is less than 3 mm, the cervical margin circumference is less than 2 mm, and the teeth are exposed to high function and lateral forces.

Material Selection in Endocrown Restorations

Composite resins, ceramics, and polyetheretherketone (PEEK) are material options for endocrowns. In dentistry, full ceramic porcelain, opaque porcelain and metal-ceramic crown restorations made with metal have begun to be preferred with aesthetic limitations and allergic reactions to the metal in some patients. All-ceramic restorations are advantageous in that they do not have any metal substructure but have sufficient strength. Nevertheless, composite resins and feldspathic glass-ceramics are not in the group recommended for endocrown restorations because they exhibit lower flexural strength and less resistance to occlusal forces compared to other materials ([31, 39]). Hybrid applications have been made in CAD/CAM applications by combining the positive properties of ceramic and composite resins to eliminate the negative aspects ([40]). Unfortunatelly, attempts to compare the block performances of composite material with ceramic blocks using meta-analysis in CAD/CAM applications could not be concluded due to a lack of standardization or reported criteria ([41]). In endocrown applications, the occlusal thickness of the ceramic material should be between 3-7 mm. In a study by Mörmann et al., it was observed that endocrowns with an occlusal thickness of 5.5 mm had higher fracture resistance of ceramic crowns with an occlusal thickness of 1.5 mm. It has been concluded that it is the best material choice for glass fiber post and composite resin cores, showing better fracture resistance than indirect conventional crowns ([31]). In the following years, in a study in which three restorations were designed with composite and lithium disilicate reinforced glass-ceramic using CAD/CAM systems, it was observed that when force is applied in the inclined plane, endocrown restorations with a depth of 2.5 mm can withstand a high level of force if they are made of composite ([42]). As concluded in another study, the depth of the pulp chamber has a significant effect on the fracture strength of endocrowns using feldspathic ceramics and destructive fractures may occur when using zirconia materials with high modulus of elasticity, whereas repairable fractures occur only when lithium disilicate, polymer infiltrated ceramics, resin ceramics and feldspathic ceramics are used ([43]). Although it has been observed that the similarity of the elastic modulus to the dentin in composite resins reduces the fracture rates, it has been mentioned that it may increase the risk of decimentation and that the biggest failure observed in endocrowns is decimentation ([44]). CAD/CAM endocrown were performed and followed up for the treatment of a severely damaged tooth diagnosed with pulpitis. With this combination, it has been stated that the biological potential of the pulp is preserved and the continuity of the endoprosthesis is ensured with the goal of long-term success ([45]). As a result, it was concluded in a recent study that materials with the highest adhesion values such as lithium disilicate may be the best choice since the strong adhesion observed in other materials is a priority problem than the risk of fracture ([44]).

CONCLUSION

Compared to other restoration options, endocrowns offer advantages in mechanical performance, cost, and clinical time. After reviewing the literature, it was determined that endocrowns could be a viable restoration option for endodontically treated teeth (ETT) with excessive coronal structure loss.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

Bu çalışma, Prof. Dr. Zühre Hale Cimilli danışmanlığında hazırlanan "Endodontik Tedavili Dişlerde Restorasyonlar: Endokron" başlıklı yüksek lisans tezinde yapılan literatür taraması esas alınarak hazırlanmıştır.

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It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

Yapıldı – ithenticate

Etik Bildirim / Ethical statement

ethic.selcukdentaljournal@hotmail.com

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Çıkar Çatışması / Conflict of Interest

Yazarlar çıkar çatışması bildirmemiştir. | The authors have no conflict of interest to declare.

Yazar Katkıları / Author Contributions

Çalışmanın Tasarlanması | Design of Study: ŞSAK (%30), ZHC (%70)
Veri Toplanması | Data Acquisition: ŞSAK (%50), ZHC (%50)
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