J Istanbul Univ Fac Dent 2015;49(2):57-63.
http://dx.doi.org/10.17096/jiufd.60136 REVIEW ARTICLE

ENDOCROWNS: REVIEW

Endokronlar: Derleme

Gaye SEVİMLİ, Seda CENGİZ, M. Selçuk ORUÇ

Received: 09/10/2013
Accepted:02/12/2014

ABSTRACT

The ideal restoration of endodontically treated teeth (ETT) has been widely and controversially discussed in the literature. Prevention of healthy dental structure is essential to help mechanical stabilization of tooth-restoration integrity, increase the amount of suitable surfaces for adhesion and thus positively affect the long-term success. ETT are affected by a higher risk of biomechanical failure than vital teeth. With the development of adhesive systems, the need for post-core restorations is also reduced. Especially for restoration of excessively damaged ETT, endocrowns have been used as an alternative to the conventional post-core and fixed partial dentures. Compared to conventional methods, good aesthetics, better mechanical performance, and less cost and clinic time are the advantages of endocrowns.

Keywords: *Endocrown; adhesive restoration; endodontically treated teeth*

ÖZ

Endodontik tedavili dişlerin ideal restorasyonu literatürde geniş yer tutan ve tartışmalı bir konudur. Sağlıklı diş dokusunu korumak, diş-restorasyon bütünlüğünün mekanik stabilizasyonunu sağlamaya yardımcı olması, adezyon için uygun yüzey miktarının artması ve böylece restoratif tedavinin uzun dönem başarısını olumlu yönde etkilemesi için gereklidir. Pulpanın uzaklaştırılması ile canlılığını kaybeden devital dişler, vital dişlere kıyasla daha yüksek biyomekanik başarısızlık riski taşımaktadırlar. Adeziv sistemlerin gelişmesiyle birlikte post-kor restorasyonlarına olan ihtiyaç da azalmaktadır. Özellikle aşırı madde kaybına sahip endodontik tedavili dişlerin restorasyonunda, geleneksel post-kor ve sabit bölümlü protezlere alternatif olarak endokron restorasyonlar kullanılmaya başlanmıştır. Geleneksel yöntemlere kıyasla endokronların estetik, mekanik performanslarının daha iyi olması, maliyetinin düşük olması ve kısa sürede yapılmaları avantajlarıdır.

Anahtar kelimeler: *Endokron; adeziv restorasyon; kanal tedavili diş*

Department of Prosthodontics Faculty of Dentistry Bülent Ecevit University

Introduction

The restoration of endodontically treated teeth (ETT) is a topic that has been widely and controversially discussed in the dental literatüre (1), and clinical opinions on this subject have been based on rather empirical philosophies due to the weak link between available scientific data and inconclusive clinical studies (2, 3). ETT carry a higher risk of biomechanical failure than vital teeth, and are a common problem in restorative dentistry related to the fractures occuring in such teeth (4).

Changes Occuring in Endodontically Treated Teeth

The primary reason for reduction in stiffness and fracture resistance of ETT is the loss of structural integrity associated with carries, trauma and extensive cavity preparation, rather than dehydration or physical changes in dentin (5). Type of restorative materials used and an appropriate restoration that conserves tooth structure are the factors affecting the longevity of endodontic treatment (6). Quality and integrity of the remaining tooth structure should be preserved carefully in terms of providing a solid base required for restoration and increasing the structural strength of the restored tooth (7-9).

Biomechanical principles indicate that the structural strength of a tooth depends on the quantity and intrinsic strength of hard tissues and the integrity of the anatomic form. Variations in tissue quality following endodontic treatment proved to have a negligible influence on tooth biomechanical behavior. Mechanically, a conservative endodontic access cavity has been found to minimally affect the fracture resistance of a tooth. Another issue is the impairment of neurosensory feedback related to the loss of pulpal tissue, which might reduce the protection of the ETT during mastication (10).

Studies are available showing that the main reason for the decrease in durability is the loss of the marginal ridges (11). Some researchers reported that endodontic access cavity and root canal preparation resulting in loss of tooth tissue increase the brittleness of teeth, rather than the changes in dentine (11, 12). In healthy human teeth, a study that compared the effect of endodontic and restorative procedures on cusp durability indicated that endodontic procedures, occlusal cavity preparations and MOD cavity preparations reduce the strength by 5%, 20% and 63%, respectively (13).

Restoration of Endodontically Treated Teeth

Although there are a number of studies on ETT, treatment planning and the choice of material for the restoration are still controversial, and some criteria must perticularly be considered. The remaining coronal tooth structure and functional requirements are important factors to be considered in deciding the treatment planning (14).

Minimal Loss of Coronal Structure

Minimal loss of coronal structure usually relates to teeth that have had little or no restoration but require root canal therapy. The remaining tooth structure, despite endodontic treatment, should present only minimal strength loss compared to a vital tooth, providing no horizontal or vertical crack is present; actually, the endodontic access cavity and minimal enlargement of the pulp chamber are considered not to significantly affect tooth biomechanics (13, 15, 16). The authors suggest treating such teeth with only adhesive restoration filling the access cavity and pulpal chamber. The choice of material should be limited to composite resins, in combination with an effective adhesive system, following the total bonding concept (17). The only contraindication to such a conservative approach is the case of patients with parafunctions, group guidance and step cuspal inclination, which may require compelete occlusal coverage (10).

Up to One-Half of the Coronal Tooth Structure Missing

Since coronal structure is enough to provide restoration stability, retention and strength, teeth with existing medium-sized restorations that require root canal therapy do not need a post-core restoration. Complete occlusal coverage, such as an endocrown or onlay restorations, is suggested, with using a composite resin liner-base (18) to create an even cavity preparation and fill undercuts (2, 13).

More Than Half of the Coronal Tooth Structure is Missing

When more tissue is missing, suitable surface and coronal structure are limited for adhesion. In this case, post-core restoration is mandatory to ensure tooth-restoration continuum strength and resistance to fracture. With the proper preparation design (maintaining 1.0-1.5 mm of the walls), remaining coronal tooth structure should provide stability against rotational forces. A ferrule effect should be attained by extending restoration margins 1.5-2.0 mm below the foundation limits (19, 20). Available scientific data and literature suggest the adhesive techniques for post and core fabrication (2). Occlusal anatomy and function are usually restored with a full crown. This option, however, presents a higher biomechanical risk of failure related directly to the amount of missing tooth structure (10).

Most of the Coronal Tooth Structure is Missing

This presents the least favorable biomechanical situation and cannot be satisfactorily or safely approached in the long term. Since orthodontic extrusion is rarely performed on pluriradicular teeth, extensive crown lengthening to attain a ferrule effect and restoration stability should no longer be considered as a feasible option. Extraction and dental implants might be then acceptable as an alternative to conventional treatment of severely compromised posterior teeth (21, 22).

Post-core Restorations

Restoration of ETT with extensive coronal loss has followed a strict protocol, with the fabrication of total crowns supported on post-cores. Initially, this protocol was thought to be providing better support for the remaining tooth structure, however, it has been observed that the use of intracanal retainers only increased the retention of prosthetic crowns (2, 23). The purpose of a post-core restoration is to stabilize the remaining coronal tooth structure and to replace missing coronal tissue (1, 2, 24-26). Some finite element analysis (FEM) studies indicated that a rigid post can strengthen a tooth in its cervical part with the help of totally cohesive interfaces (4, 27), but most studies suggested that posts have no strengthening effect (2). In fact, when present restorative techniques and materials are used, in well-selected situations, posts are considered only as a retentive feature. Other *in vitro* studies have shown that there is no difference in retention, marginal adaptation and fracture resistance between a vital tooth configuration and a nonvital tooth with a fiber-post supported onlay restoration (28). Their role of maintaining the core material is particulary relevant for posterior teeth, where masticatory loads are essentially compressive (26), however, when loaded transversely, as in the case of incisors, the flexural behavior of posts should be carefully considered (29). The characteristics of the interfaces and the rigidity of the materials strongly influence the mechanical behavior of ETT restored with posts, and many authors even discourage the use of posts in consideration of various risks such as root perforation and weakness (2, 4).

Amalcore Restorations

Nayyar *et al*. (30) described the amalcore or coronal-radicular restoration. In this technique, amalgam was placed into the pulpal chamber, entering 2 to 4 mm into the canal. The remaining pulp chamber should be of sufficient width and depth to provide adequate bulk and retention of the amalgam restoration. An adequate dentin thickness around the pulp chamber was required for the tooth-restoration continuum rigidity and strength. This restoration has been found to be successful in both laboratory and clinical studies (1, 7, 11).

Endocrown Restorations

The true breakthrough in the restoration of endodontically treated teeth was the introduction of adhesion, propelled by the development of effective dentin adhesives (31). The chief advantage of adhesive restorations is that macroretentive elements are no longer mandotary as long as enough surface is available. With this approach, the insertion of radicular posts has become the exception rather than the rule when applying conventional restorative techniques. In fact, minimally invasive preparations, with maximal tissue conservation, are now considered 'the gold standard' for restoring ETT (2). By following this rationale, endocrowns are applied as a proshetic option in restoration of endodontically treated incisors (4), premolars (32) and molars (23, 33) with excessive tissue loss. Pissis (34) was the forerunner of the endocrown technique and has described it as the 'mono-block porcelain technique'. In 1999, the endocrown was described for the first time by Bindle and Mörmann as adhesive endodontic crowns and characterized as total porcelain crowns fixed to endodontically treated posterior teeth (35). These crowns would be anchored to the internal portion of the pulp chamber and on the cavity margins, so macromechanical retention is provided by the pulpal walls, and micromechanical retention is obtained by the use of adhesive cementation. This method is particularly indicated in cases in which there is excessive loss of tissue of the crown, interproximal space is limited and traditional rehabilitation with post and crown is not possible because of inadequate ceramic thickness (5). Compared to conventional crowns, endocrowns are easy to apply and require a short clinical time. Low cost, short preparation time, ease of application, minimal chair time and aesthetic properties are the advantages of endocrowns (2). In addition, endocrowns are also an alternative in teeth with short or atresic clinical crowns, calcified, curved or short root canals that make post application impossible (23). In a study of 3D Finite Element Analysis of molars restored with endocrowns and posts during masticatory simulation, teeth restored by endocrowns were potentially more resistant to failure than those with fiber reinforced posts (36).

Preparation Technique for Endocrowns

The endocrown preparation consists of a circumferential 1.0-1.2 mm depth butt margin and a central retention cavity inside the pulp chamber, constructs both the crown and core as a single unit monoblock structure, and does not take support from the root canals (34, 35). The suggested dimensions are a 3 mm diameter cylindrical pivot and a 5 mm depth fort the first maxillary premolars and a 5 mm diameter and a 5 mm depth for molars (34), but the precise dimensions for the preparation of central retention cavity were not clearly determined (5). The thickness of the ceramic occlusal portion of endocrowns is usually 3-7 mm. An *in vitro* study showed that the fracture resistance of ceramic crowns increases with increasing occlusal thickness (37). Mörmann *et al.* (38) reported that the fracture resistance of endocrowns with an occlusal thickness of 5.5 mm was two times higher than that of ceramic crowns with a classic preparation and an occlusal thickness of 1.5 mm. In a clinical study, Bindl and Mörmann evaluated the performance of 208 endocrowns cemented to premolars and molars, and observed that the premolars presented more failures than the molars because of the adhesion loss on these teeth (33). Loss of adhesion of endocrowns on premolars is suggested to be due to the surface of adhesive bonding was smaller than the one on molars, and the greater ratio of the prepared tooth structure to the overall crown might have caused a higher leverage for premolars than for molars.

Restorative Material Selection

With the advent of adhesive dentistry, the need for using posts-cores has decreased. Moreover, the appearence of ceramics that had high mechanical strength and were capable of being acid etched (such as those reinforced with leucite or lithium disilicate), allied with the adhesive systems and resinous cements, made it possible to restore posterior teeth, especially molars, without cores and intraradicular posts (39).

Indirect composite and porcelain laboratory systems are the alternative restoration options for wide cavities in posterior teeth. Fabricated in laboratory, indirect porcelain or composite resin inlays rehabilitate the mechanical and biological function while providing optimum aesthetics with minimal tooth preparation. Both porcelain and indirect resins ensure excellent marginal fit, ideal proximal contacts, high wear resistance, reduced polymerization shrinkage and optimal aesthetics (6). Ceramic restorations can be made in the laboratory or using CAD/CAM systems by processing the feldspathic ceramic blocks (40). Industrially optimized feldspathic ceramics are used in CAD/CAM systems and when compared to dental ceramic materials processed in the laboratory, they have better fracture strength and structural homogeneity. The preparation is suitable for the conservative and modern preparation design. In addition, the restoration can be completed in a single session, and good marginal fit and aesthetics are obtained (41).

Chang *et al.* (5) compared the fracture resistance and failure modes of CEREC endocrowns with the conventional post-core supported CEREC crowns on maxillary premolars. It is reported that the CEREC endocrowns showed a higher fracture resistance than conventional crowns, but regarding failure modes, no significant difference was found between the two groups. In an *in vivo* study, Bindl and Mörmann (35) reported that 19 adhesively bonded CEREC endocrowns (4 premolars and 15 molars) in 13 patients functioned satisfactorily for 28 months, and only one endocrown failed because of recurrent caries. An *in vitro* study, assessing marginal leakage and fracture resistance of 3 different CAD/CAM fabricated ceramic endocrowns from feldspathic porcelain, lithium disilicate and resin nanoceramic on maxillary molars showed that resin nanoceramic endocrowns have significantly higher fracture resistance and more favorable fracture mode, but also higher dye penetration and more microleakage than feldspathic porcelain and lithium disilicate endocrowns (42). In an *in vitro* study on mandibular molars, the fracture strength of lithium disilicate reinforced ceramic endocrowns and glass fiber post supported conventional crowns was compared and the results showed higher fracture strength for endocrowns when compared to conventional crowns; and it is suggested that endocrowns must be made only with reinforced ceramics. Moreover, the failure pattern was similar for both groups and characterized by fracture of tooth associated with displacement of the restoration (23). Polymerization of indirect laboratory composite systems is performed by different types of polymerization, such as heat, light, pressure, vacuum, nitrogen or combinations of these. By reducing polymerization shrinkage, bending strength, tensile strength, abrasion resistance, fracture resistance and color stability values are increased (43).

Nowadays, fiber-reinforced composite systems has made the transition from intracoronal restorations to crown and bridge restorations, by increasing the physical, mechanical and aesthetic properties; so they are a good alternative to ceramic and resin materials (44, 45). On the other hand, CAD-CAM crowns fabricated from millable composite resin blocks offer a superior option to all-ceramic crowns in regard to marginal adaptation (46). In a study on adhesive restorations of endodontically treated anterior teeth, the fracture resistance and failure modes of endodontically treated maxillary incisors restored with endocrowns made of composite or ceramic blocks were evaluated and no significant differences between the groups were observed. The similar flexural strength values of composite and ceramic CAD/CAM blocks and ferrule effect were emphasized as these might have been important in achieving these results (47).

Zarone *et al.* (4) presented a 3D FE model of a maxillary central incisor with different restoring configurations and materials. Composite, syntered alumina, feldspathic ceramic endocrowns and syntered alumina, feldspathic ceramic glass fiber post supported crowns were tested in the study. It is concluded that high stiffness materials, such as alumina, cause stresses in the interfaces and have a negative impact on the biomechanical properties of the restorations. On the contrary, low stiffness materials, as composite resins, were found to accompany the natural flexural features of tooth and reduce the stresses arising at the interfaces.

Cementation

To date, resin cements composed of Bis-GMA or UDMA resin matrix and inorganic filler particules are the most popular types of cements. When compared to conventional cements, with superior mechanical and aesthetic properties, resin cements have an increasing use in cementation of ceramic, metal and composite indirect restorations (48). Usually eugenol-containing root canal sealers are believed to inhibit the polymerization of resin cements. This problem may be overcome by cleaning of the root canal walls and acid etching. Cleaning all of the gutta percha and eugenol-containing root canal sealer in the canal is difficult without removing dental tissue. Debris on the rough surfaces of the root canal prevents the adequate roughen of dentin and polymerization of resin cement. However, in an *in vitro* study, it has been reported that eugenol-containing pastes do not have a negative effect on the bond strength of resins (41). Lin *et al*. (32) evaluated the risk of failure for an endodontically treated premolar with MOD preparation and three different CEREC ceramic restoration configurations. Ceramic restorations were cemented adhesively by composite resin cement, and simulations were performed based on three 3D finite element models desinged with CEREC ceramic inlay, endocrown and conventional crown restorations. Results indicated that the stress values on the enamel, dentin and luting cement for endocrown restorations were the lowest ones among the values for inlay and conventional crown restorations. For normal biting, Weibull analysis showed that failure probability was 95%, 2% and 2% for the inlay, endocrown and conventional crown restorations, respectively. Both light- and dual-polymerizable luting resins can be adequately polymerized when they are used for luting thick indirect endocrown restorations (49).

Conclusion

Endocrowns have been used as an alternative to conventional post-core and fixed partial dentures in restoration of ETT with extensive coronal tissue loss. Compared to traditional methods, better aesthetics and mechanical performance, low cost and short clinical time are the advantages of endocrowns.

Source of funding
None declared

Conflict of interest
None declared

References

1. Robbins JW. Restoration of the endodontically treated tooth. Dent Clin North Am 2002;46(2):367-384.
2. Dietschi D, Duc O, Krejci I, Sadan A. Biomechanical considerations for the restoration of endodontically treated teeth: A systematic review of the literature, part ii (evaluation of fatigue behavior, interfaces, and in vivo studies). Quintessence Int 2008;39(2):117-129.
3. Morgano SM, Hashem AF, Fotoohi K, Rose L. A nationwide survey of contemporary philosophies and techniques of restoring endodontically treated teeth. J Prosthet Dent 1994;72(3):259-267.
4. Zarone F, Sorrentino R, Apicella D, Valentino B, Ferrari M, Aversa R, Apicella A. Evaluation of the biomechanical behavior of maxillary central incisors restored by means of endocrowns compared to a natural tooth: A 3d static linear finite elements analysis. Dent Mater 2006;22(11):1035-1044.
5. Chang CY KJ, Lin YS, Chang YH. Fracture resistance and failure modes of CEREC endo-crowns and conventional post and core-supported CEREC crowns. J Dent Sci 2009;4(3):110-117.
6. Ferrari M, Vichi A, Mannocci F, Mason PN. Retrospective study of the clinical performance of fiber posts. Am J Dent 2000;13(Spec No):9B-13B.
7. Assif D, Nissan J, Gafni Y, Gordon M. Assessment of the resistance to fracture of endodontically treated molars restored with amalgam. J Prosthet Dent 2003;89(5):462-465.
8. Johnson JK, Schwartz NL, Blackwell RT. Evaluation and restoration of endodontically treated posterior teeth. J Am Dent Assoc 1976;93(3):597-605.
9. Linn J, Messer HH. Effect of restorative procedures on the strength of endodontically treated molars. J Endod 1994;20(10):479-485.
10. Lander E, Dietschi D. Endocrowns: A clinical report. Quintessence Int 2008;39(2):99-106.
11. Reeh ES, Douglas WH, Messer HH. Stiffness of endodontically-treated teeth related to restoration technique. J Dent Res 1989;68(11):1540-1544.
12. Oliveira Fde C, Denehy GE, Boyer DB. Fracture resistance of endodontically prepared teeth using various restorative materials. J Am Dent Assoc 1987;115(1):57-60.
13. Reeh ES, Messer HH, Douglas WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. J Endod 1989;15(11):512-516.
14. Faria AC, Rodrigues RC, de Almeida Antunes RP, de Mattos Mda G, Ribeiro RF. Endodontically treated teeth: Characteristics and considerations to restore them. J Prosthodont Res 2011;55(2):69-74.
15. Papa J, Cain C, Messer HH. Moisture content of vital vs endodontically treated teeth. Endod Dent Traumatol 1994;10(2):91-93.
16. Trope M, Ray HL, Jr. Resistance to fracture of endodontically treated roots. Oral Surg Oral Med Oral Pathol 1992;73(1):99-102.
17. Krejci I, Stavridakis M. New perspectives on dentin adhesion--differing methods of bonding. Pract Periodontics Aesthet Dent 2000;12(8):727-732.
18. Dietschi D, Spreafico R. Current clinical concepts for adhesive cementation of tooth-colored posterior restorations. Pract Periodontics Aesthet Dent 1998;10(1):47-54.
19. Cathro PR, Chandler NP, Hood JA. Impact resistance of crowned endodontically treated central incisors with internal composite cores. Endod Dent Traumatol 1996;12(3):124-128.
20. Sorensen JA, Engelman MJ. Ferrule design and fracture resistance of endodontically treated teeth. J Prosthet Dent 1990;63(5):529-536.
21. Cho GC. Evidence-based approach for treatment planning options for the extensively damaged dentition. J Calif Dent Assoc 2004;32(12):983-990.
22. Mordohai N, Reshad M, Jivraj SA. To extract or not to extract? Factors that affect individual tooth prognosis. J Calif Dent Assoc 2005;33(4):319-328.
23. Biacchi GR, Basting RT. Comparison of fracture strength of endocrowns and glass fiber post-retained conventional crowns. Oper Dent 2012;37(2):130-136.
24. Christensen GJ. Posts: Necessary or unnecessary? J Am Dent Assoc 1996;127(10):1522-1524, 1526.
25. Gohring TN, Peters OA. Restoration of endodontically treated teeth without posts. Am J Dent 2003;16(5):313-317.
26. Guzy GE, Nicholls JI. In vitro comparison of intact endodontically treated teeth with and without endo-post reinforcement. J Prosthet Dent 1979;42(1):39-44.

27. Pierrisnard L, Bohin F, Renault P, Barquins M. Corono-radicular reconstruction of pulpless teeth: A mechanical study using finite element analysis. J Prosthet Dent 2002;88(4):442-448.
28. Krejci I, Duc O, Dietschi D, de Campos E. Marginal adaptation, retention and fracture resistance of adhesive composite restorations on devital teeth with and without posts. Oper Dent 2003;28(2):127-135.
29. Heydecke G, Butz F, Strub JR. Fracture strength and survival rate of endodontically treated maxillary incisors with approximal cavities after restoration with different post and core systems: An in-vitro study. J Dent 2001;29(6):427-433.
30. Nayyar A, Walton RE, Leonard LA. An amalgam coronal-radicular dowel and core technique for endodontically treated posterior teeth. J Prosthet Dent 1980;43(5):511-515.
31. Van Meerbeek B, Perdigao J, Lambrechts P, Vanherle G. The clinical performance of adhesives. J Dent 1998;26(1):1-20.
32. Lin CL, Chang YH, Pai CA. Evaluation of failure risks in ceramic restorations for endodontically treated premolar with mod preparation. Dent Mater 2011;27(5):431-438.
33. Bindl A, Richter B, Mormann WH. Survival of ceramic computer-aided design/manufacturing crowns bonded to preparations with reduced macroretention geometry. Int J Prosthodont 2005;18(3):219-224.
34. Pissis P. Fabrication of a metal-free ceramic restoration utilizing the monobloc technique. Pract Periodontics Aesthet Dent 1995;7(5):83-94.
35. Bindl A, Mormann WH. Clinical evaluation of adhesively placed cerec endo-crowns after 2 years--preliminary results. J Adhes Dent 1999;1(3):255-265.
36. Dejak B, Mlotkowski A. 3d-finite element analysis of molars restored with endocrowns and posts during masticatory simulation. Dent Mater 2013;29(12):e309-317.
37. Tsai YL, Petsche PE, Anusavice KJ, Yang MC. Influence of glass-ceramic thickness on hertzian and bulk fracture mechanisms. Int J Prosthodont 1998;11(1):27-32.
38. Mormann WH, Bindl A, Luthy H, Rathke A. Effects of preparation and luting system on all-ceramic computer-generated crowns. Int J Prosthodont 1998;11(4):333-339.
39. Valentina V AT, Dejan L, Vojkan L. Restoring endodontically treated teeth with all-ceramic endo-crowns: case report. Stom Glass S 2008;55(1):54-64.
40. Jedynakiewicz NM, Martin N. Cerec: Science, research, and clinical application. Compend Contin Educ Dent 2001;22(6 Suppl):7-13.
41. Altıncı P. Kiremitçi A. Endodontik tedavili dişlerin restorasyonu. Hacettepe Dis Hek Fak Derg 2007;31(3):102-113.
42. El-Damanhoury HM, Haj-Ali RN, Platt JA. Fracture resistance and microleakage of endocrowns utilizing three cad-cam blocks. Oper Dent 2015;40(2):201-210.
43. Terry DA, Leinfelder KF, Maragos C. Developing form, function, and natural aesthetics with laboratory-processed composite resin--part i. Pract Proced Aesthet Dent 2005;17(5):313-318; quiz 320.
44. Gohring TN, Gallo L, Luthy H. Effect of water storage, thermocycling, the incorporation and site of placement of glass-fibers on the flexural strength of veneering composite. Dent Mater 2005;21(8):761-772.
45. Ku CW, Park SW, Yang HS. Comparison of the fracture strengths of metal-ceramic crowns and three ceromer crowns. J Prosthet Dent 2002;88(2):170-175.
46. Ramirez-Sebastia A, Bortolotto T, Roig M, Krejci I. Composite vs ceramic computer-aided design/computer-assisted manufacturing crowns in endodontically treated teeth: Analysis of marginal adaptation. Oper Dent 2013;38(6):663-673.
47. Ramirez-Sebastia A, Bortolotto T, Cattani-Lorente M, Giner L, Roig M, Krejci I. Adhesive restoration of anterior endodontically treated teeth: Influence of post length on fracture strength. Clin Oral Investig 2014;18(2):545-554.
48. McCabe JF, Walls AWG. Application of dental materials. 8th Ed., Madlen: Blackwell Science; 1998, p. 189-201.
49. Gregor L, Bouillaguet S, Onisor I, Ardu S, Krejci I, Rocca GT. Microhardness of light- and dual-polymerizable luting resins polymerized through 7.5-mm-thick endocrowns. J Prosthet Dent 2014;112(4):942-948.

Corresponding Author:
SEDA CENGİZ
Department of Prosthodontics
Faculty of Dentistry Bülent Ecevit University
Zonguldak / TURKEY
Phone: 0 372 261 36 00
e-mail: sedabc@hotmail.com