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Coronal restoration of endodontically treated posterior teeth: A review

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***Abstract*---**There is still no consensus on the restoration of endodontically treated posterior teeth in the most appropriate way. With the development of adhesive materials with improved properties

and a shift in approach towards minimally invasive dentistry, there is a paradigm change in the restorative modalities of root-filled teeth. Conventionally endodontically treated teeth were restored with post and core followed by a crown, but conservative restorative options have gained popularity with the advancements in adhesive techniques. Many studies have been done, but there is a need to re-explore the scholarly literature with the changing trend. This review article provides a brief overview of the literature on the survival of endodontically treated posterior teeth in relation to the type of post endodontic restoration. A literature search of papers related to the survival of endodontically treated teeth and type of post endodontic restorations published till July 2021 was undertaken in PubMed, MEDLINE, SCOPUS, Web of Science and Science direct. A few of the keywords searched were: post endodontic restorations, survival, clinical performance, root canal treated teeth, endodontically treated teeth, success, resin composite, crown, cuspal coverage restoration. This article also describes the factors determining the survival of root canal treated teeth, pre-restorative evaluation and recent post endodontic restorative protocols to improve clinical performance.

***Keywords*---**Post-endodontic restoration, endodontically treated teeth, root canal treated teeth.

Introduction

Root canal treated teeth show loss of dental hard tissues due to caries, trauma and endodontic procedures, making the tooth more susceptible to fracture. Hence, endodontically treated teeth need to be restored such that they would provide strength to the tooth. The survival rates of teeth following root canal treatment vary between 86% and 93% for 2-10 years (1). Studies evaluating the survival of endodontically treated teeth instead of their success based on radiographic and clinical findings have emphasized the significance of post-endodontic restoration on long-term prognosis (2). The success rate of root canal treatment is high, but if the coronal restoration is not appropriate, the endodontically treated teeth have to be extracted. 59.4% of endodontically treated teeth have failed due to inappropriate coronal restoration, whereas only 8.6% because of poor quality of endodontic treatment (3). There is limited literature available on the sole influence of post-endodontic restorations on the clinical performance of endodontically treated teeth. This review aims to assess the literature on the contemporary restorative approach for endodontically treated posterior teeth and provide guidance on current trends in adhesive restoration modalities that would stall the restorative cycle and warrant long-term survival of the root filled teeth.

Search strategy

This review is based on a literature search of articles in PubMed, MEDLINE, SCOPUS, Web of Science and Science direct published till July 2021 related to the survival of endodontically treated teeth and type of post endodontic

restorations. The following and other keywords searched were: post endodontic restorations, survival, clinical performance, root-filled, root canal treated teeth, endodontically treated teeth, success, resin composite, crown, cuspal coverage and direct restoration.

Factors affecting restorability of endodontically treated teeth

To warrant the prognosis of endodontically treated teeth following factors should be assessed before finalizing the treatment plan.

1. Amount of remaining coronal sound tooth structure
2. Crown root ratio
3. Importance of the tooth in the treatment plan
4. Determining the occlusal load on the tooth
   The occlusal load on the tooth should be analyzed before the treatment planning. If there is excessive attrition, then it suggests catastrophic loading, which would lead to either tooth fracture or post fracture or debonding of adhesive restoration in endodontically treated teeth(4). Parafunctional forces are several times more than the regular masticatory forces; hence occlusal interferences should be removed, and occlusal adjustment carried out to reduce the risk of failure (5).
5. Anatomic Position of the tooth in the dental arch
   The location of the tooth in the dental arch should be considered before the treatment is planned. In posterior teeth, elasticity plays a vital role as compressive forces dominate (6), whereas flexural stresses dominate with anterior teeth (7); hence rigidity is an important aspect.
6. Periodontal status

Restorative modalities for endodontically treated posterior teeth:
Intra radicular Posts

The conventional approach for restoring endodontically treated teeth is post and core, followed by full crown placement. Endodontically treated teeth with extensive loss of tooth structure require placement of post that would facilitate the retention of core, though they do not reinforce the root (8). Studies have pointed out that the presence of ferrule redistributes the applied stresses and significantly contributes to fracture resistance in nonvital teeth restored with post and core(9). The selection of the type of post to be used depends on the amount of residual coronal tooth structure. Fiber post can be used when there is a sufficient amount of remaining coronal dental hard tissue, whereas, cast posts are indicated in the case of moderate to severe tooth structure loss. Cast post and core is a time-consuming, laborious technique and involves laboratory procedures, making it an expensive modality. In contrast, prefabricated fiber posts can be completed in one visit and do not involve laboratory process and hence is a less expensive procedure (10). A meta-analysis by Zhou et al. comparing fracture resistance of cast post and fiber posts showed that the endodontically treated teeth restored with cast post and core were associated with catastrophic fractures in the middle third of the root or vertical fractures. In contrast, in the case of teeth restored with fiber posts, the failures were repairable, and that the fractures were in the cervical third of the root (11). This may be explained by the fact that the elastic modulus of fiber post is similar to

that of dentin, which contributes to the distribution of stresses. On the other hand, cast posts have a much higher elastic modulus than dentin and hence stress concentration in the root leading to unfavorable root fractures (11,9). 3D Finite Element studies have demonstrated that restorative materials like composite resin with elastic modulus comparable to dentine contribute to a more favorable outcome in endodontically treated teeth. Nevertheless, failures are still a concern when fiber posts are used for the restoration of root-filled teeth.

Studies have demonstrated that post placement does not provide resistance to root canal treated teeth but may cause unfavorable fractures of the root; hence the use of posts in endodontically treated teeth is questionable (12,13). Post space preparation requires further removal of tooth structure that would compromise the strength of the tooth; hence decision to use the posts should be based on risk versus benefit assessment. An endodontically treated teeth with limited structure loss, placement of post does not offer any advantage (14,15). Hence postless approach should be considered to increase the survival rate.

Role of Ferrule

Various studies have been done to evaluate the effect of the ferrule on endodontically treated teeth, and it is suggested that the use of 1.5-2 mm of ferrule reinforces the fracture resistance of root-filled teeth (16). With the advancements in adhesive techniques, endodontically treated teeth with 2mm ferrule are restored with composite resin cores but without posts against conventional techniques using post and core build-ups (14).

Indirect Full Coverage Restorations

a. Cast Gold Restorations
   Cast gold crowns have been traditionally used to restore root-filled teeth because of their excellent durability and functional performance. However, with the technological development of ceramic and adhesive composite resin materials, these materials have become the choice of clinicians due to their superior esthetic properties and high clinical success.
b. Metal Ceramic Crowns
   Metal ceramic crowns are used widely and are considered the gold standard for restoring endodontically treated teeth. A retrospective study has shown that the survival rate for metal-ceramic crowns on root canal treated teeth with post and core was 93%, without post and core 83%, and in vital teeth, it was 94%. Studies have shown that the most common cause for the failure of metal-ceramic crowns is the development of caries (15).
c. All-Ceramic Crowns
   All ceramic materials have become the preferred treatment option due to their excellent esthetics and good mechanical stability. A meta-analysis showed that five year survival rates of glass infiltrated alumina crowns, lithium disilicate reinforced glass-ceramic crowns, densely sintered alumina and zirconia crowns were equivalent to that of metal-ceramic crowns (94.7%). They also concluded that silica-based ceramic and zirconia crowns for posterior teeth showed a significantly lower five-year survival rate. Silica-based ceramic can be considered for anterior restorations; however, densely sintered zirconia crowns are not recommended as they are associated with

the chipping of ceramic veneer and loss of retention (17). The most frequent cause of failure with all-ceramic crowns is the core fracture, whereas, with metal-ceramic crown, complications are mostly related to chipping of ceramic, caries and periodontitis (18).

Indirect Cast Partial Coverage Restorations

a. Onlays
   Partial coverage restorations like onlays offer an alternative to full coverage crowns for reinforcing the tooth structure in root canal treated teeth. The advantage of onlays is that they provide cuspal coverage and conserve the remaining tooth structure compared to full coverage crowns. Materials that can be used to fabricate cast onlays are gold and ceramic. With the increase in demand for esthetic restorations and advancements in adhesive techniques, indirect ceramic onlays offer an excellent restorative option. Lithium disilicate ceramics with enhanced mechanical properties satisfy the functional as well as esthetic demands of the patient (19).
b. Endocrowns
   Use of posts in nonvital teeth aids in the retention of the core but leads to further removal of intact tooth structure for post preparation. This leads to weakening of the tooth and hence the risk of irreversible fracture of the root. In case of such catastrophic failures, extraction of the tooth is the only option. An alternative to the use of posts in restoring the nonvital tooth is the use of endodcrowns. An endocrown is a bonded monolithic ceramic restoration that uses a pulp chamber to extend the crown following the monobloc concept.

   Studies comparing survival rates of crowns and endocrowns on molars have concluded no statistical difference in the survival rates between the two modalities over a study period of 7 to12 years (20,21). Otto et al. have concluded in their study that the 12-year survival rate of ceramic crowns on molars was 95%, whereas that of endocrowns was 90.5%, and these differences were not statistically significant (20). In their study assessing the biomechanical failure risk for root canal treated premolars, Lin et al. have demonstrated that under normal occlusion, both the CAD/CAM ceramic endocrowns as well as conventional crowns performed equally and that endocrowns could serve as a conservative and suitable modality for restoration of endodontically treated maxillary premolars (22).

Adhesive Composite Resin Restorations

There is a paradigm shift from conventional methods of restoration of endodontically treated teeth based on mechanical retention to current methods based on adhesion (23). This is due to the development of composite resins with enhanced physical properties and current adhesive systems. Several studies have demonstrated mechanically retained restorations as reliable options for the restoration of root canal treated teeth (24,25), but they compromise with the biological aspect, whereas adhesive restorations conserve the natural tooth structure and serve as a better alternative for restoring endodontically treated teeth.

Adhesive restorative approach for restoring endodontically treated teeth may be either direct composite restorations or indirect composite resin inlays or onlays.

a. Indirect Composite Restorations
   The advantages of indirect composite inlays and onlays are reduced polymerization stress as it involves extraoral polymerization of the resin, better restoration of anatomic contacts and, contours and enhanced surface finish (26).

   Krejci et al., in their study, have demonstrated that minimally invasive adhesive restorative modality shows promising results for restoration of endodontically treated teeth. They have also concluded that in an adhesive restorative approach, placement of posts have no significant influence on retention (27).

   Newer resin materials, Cerasmart and Enamic for chairside CAD-CAM, have been developed with improved properties. A retrospective study on indirect composite resin onlays placed on endodontically treated teeth has shown a survival rate of 96.8% (28). Limited studies on the long-term clinical performance of indirect composite restorations on root canal treated teeth are available.

b. Direct Composites Restorations:
   Recent advances in material science technology have resulted in composite resins with good wear resistance and durability and expanded their clinical applications (29). However, the main concern with the use of composite resins is stresses due to polymerization shrinkage. This shortcoming can be compensated using an incremental filling technique, stress absorbing cavity liner or base of flowable composite resin, or soft start or pulse delay curing techniques (29).

   The results of the retrospective study conducted by Dammaschke et al. (2013) showed that there were no significant differences between the type of teeth, its location in the arch, age and gender of the patient, but the post endodontic restorative material significantly influenced the fracture toughness of the root canal treated teeth. The mean survival period of root canal treated teeth with crowns, composite restorations and amalgam fillings was 15.3 years, 13.4 years, and 11.8 years respectively. They also concluded that cavities with up to three surfaces could be restored successfully with adhesive composite resins (30).

Discussion

A study by Lynch et al. 2004 (31) on survival of root-filled teeth has shown that out of 176 teeth, 91.7% of teeth restored with cast restorations, 86.5% with amalgam restorations, and 83% with composite resin as post endodontic restoration survived over a mean span of 38 months. However, these retrospective studies are vulnerable to selection bias, and also they do not give details about the reasons for failure.

Toure et al. (32) analyzed the factors for extraction of root canal treated teeth and found out that though out of 119 extracted teeth, 94% were those without full cuspal coverage restorations, but out of these, 40.3% were extracted due to periodontal pathology and 20% due to endodontic failures, and hence the reason stated being no cuspal coverage could not be justified (15). A systematic review concluded that there is limited evidence to determine whether crowns are beneficial as compared to direct fillings as post endodontic restorations (33).

A systematic review comparing the direct and indirect restorations on root-filled teeth summarized that there is higher 10-year survival for teeth restored with indirect restorations; however, short-term or five-year survival rates showed no significant difference. However, the limitation with this study was that the inference was based on retrospective studies with materials of the 1990s, and there is a need for high-quality clinical trials with better control of confounding factors (34). Also, most studies evaluating direct restorative materials have not assessed amalgam and composite resin separately, but the results are pooled together.

Studies have shown that although ceramic restorations for endodontically treated teeth provide more fracture strength but result in a higher rate of catastrophic fractures than adhesive composite resin restorations. The thermomechanical loading study by Frankenberger et al. demonstrated that with similar cavity preparation designs, there was no difference between ceramic restorations and direct restorations and that endodontic access cavities can be successfully restored with direct adhesive composite resins (35).

The study conducted by Aboobaker et al. has shown that fracture resistance of root canal treated teeth can be increased by creating intra orifice barriers using GIC, flowable composite resins, MTA or Biodentine (36). RF Mondelli et al., in their study, concluded that cuspal coverage with condensable composite resin improves the clinical performance of weakened root canal treated teeth (37).

An in vitro study showed no significant difference in the fracture resistance of endodontically treated molars restored with cuspal capping with direct and indirect composite resin (38). Cuspal coverage strengthens the fracture resistance of the teeth, and that for composite resin restorations, there was no difference in fracture load between direct and indirect techniques (39). Also, advantages with the direct technique are that it preserves the tooth structure and hence increased strength of the tooth, ease of repair and modification, less time consuming and economical as does not involve added laboratory cost.

Literature search has revealed studies stating an increased risk of fracture of root canal treated teeth, and that cuspal coverage would improve their longevity (28,29). But the drawback with these studies was that they did not consider the amount of residual tooth structure. Endodontically treated teeth with loss of both the marginal ridges will have more fracture risk than the tooth with just an occlusal endodontic access cavity (40). Hence tooth preparation for cuspal coverage in the latter case would result in comprising the tooth's strength. Considering this, endodontically treated posterior teeth are divided into three

types based on loss of tooth structure: minimally destructed teeth, moderately destructed and severely destructed endodontically treated teeth (41).

Endodontically treated teeth with only occlusal access cavity or with loss of only one of the marginal ridges with remaining axial walls of $\geq$ 2mm thickness are categorized as minimally destructed teeth. It is suggested that with such cases, cuspal coverage restorations are not indicated.[41] This concept is in agreement with the study by Dammaschke et al., where they established that endodontically treated teeth with three axial walls could be effectively restored with adhesive composite resins (30). Moderately destructed endodontically treated teeth are Meiso-occlusal or distoocclusal cavities with axial wall thickness of <2mm or mesio-occluso-distal cavities (MOD) (42). Cuspal coverage would be beneficial for clinical success in this category (43).

When the tooth structure loss is more than that of MOD cavity, it is categorized as a severely destructed tooth. For the long-term prognosis of such cases, cuspal coverage restorations with intraradicular retention would be advantageous (42).
Nevertheless, due to variability in the studies, controversy still exists regarding the restoration protocols for endodontically treated posterior teeth. More prospective clinical trials are needed to clarify the best way to restore root-filled posterior teeth.

Conclusion

The type of coronal restoration influences the prognosis of endodontically treated posterior teeth, which are already compromised due to loss of tooth structure. Hence the restorative modality and the material should be such that it preserves the natural tooth substance and positively impacts the clinical survival of the teeth. Future prospective in-vivo trials assessing the clinical performance of root canal treated posterior teeth with a modest loss of coronal structure and restored with minimally invasive adhesive composite resin restorations would be of great significance.

References

1. Ng Y-L, Mann V, Gulabivala & K. Tooth survival following non-surgical root canal treatment: a systematic review of the literature. Int Endod J. 2010;43:171-189. doi:10.1111/j.1365-2591.2009.01671.x
2. Landys Borén D, Jonasson P, Kvist T. Long-term survival of endodontically treated teeth at a public dental specialist clinic. J Endod. 2015;41(2):176-181. doi:10.1016/j.joen.2014.10.002
3. \/ire DE. Failure of endodontically treated teeth: classification and evaluation. J Endod. 1991;17(7):338-342.
4. Vârlan C, Dimitriu B, Vârlan V, Bodnar D, Suciu I. Current opinions concerning the restoration of endodontically treated teeth: basic principles. J Med Life. 2009;2(2):165-172.
5. Trushkowsky RD. Restoration of endodontically treated teeth: criteria and technique considerations. Quintessence Int. 2014;45(7):557-567. doi:10.3290/j.qi.a31964
6. Pedrollo Lise D, Van Ende A, De Munck J, Umeda Suzuki TY, Cardoso Vieira

LC, Van Meerbeek B. Biomechanical behavior of endodontically treated premolars using different preparation designs and CAD/CAM materials. J Dent. 2017;59:54-61. doi:10.1016/j.jdent.2017.02.007
7. Magne P DW. Cumulative effects of successive restorative procedures on anterior crown flexure: intact versus veneered incisors. Quintessence Int. 2000;31(1):5-18. https://pubmed.ncbi.nlm.nih.gov/11203907/
8. 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. http://www.ncbi.nlm.nih.gov/pubmed/18560650
9. Goracci C, Ferrari M. Current perspectives on post systems: A literature review. Aust Dent J. 2011;56(SUPPL. 1):77-83. doi:10.1111/j.1834-7819.2010.01298.x
10. Heydecke G, Peters MC. The restoration of endodontically treated, single-rooted teeth with cast or direct posts and cores: A systematic review. J Prosthet Dent. 2002;87(4):380-386. doi:10.1067/mpr.2002.123848
11. Zhou L, Wang Q. Comparison of fracture resistance between cast posts and fiber posts: A meta-analysis of literature. J Endod. 2013;39(1):11-15. doi:10.1016/j.joen.2012.09.026
12. Magne P, Goldberg J, Edelhoff D, Güth JF. Composite resin core buildups with and without post for the restoration of endodontically treated molars without ferrule. Oper Dent. 2016;41(1):64-75. doi:10.2341/14-258-L
13. Güth JF, Edelhoff D, Goldberg J, Magne P. CAD/CAM polymer vs direct composite resin core buildups for endodontically treated molars without ferrule. Oper Dent. 2016;41(1):53-63. doi:10.2341/14-256-L
14. Naumann M, Schmitter M, Frankenberger R, Krastl G. “Ferrule Comes First. Post Is Second!” Fake News and Alternative Facts? A Systematic Review. J Endod. 2018;44(2):212-219. doi:10.1016/j.joen.2017.09.020
15. Bhuva B, Giovarruscio M, Rahim N, Bitter K, Mannocci & F. The restoration of root filled teeth: a review of the clinical literature. Int Endod J. 2020;54:509-35.doi:10.1111/iej.13438
16. Juloski J, Radovic I, Goracci C, Vulicevic ZR, Ferrari M. Ferrule effect: A literature review. J Endod. 2012;38(1):11-19. doi:10.1016/j.joen.2011.09.024
17. Sailer I, Makarov NA, Thoma DS, Zwahlen M, Pjetursson BE. All-ceramic or metal-ceramic tooth-supported fixed dental prostheses (FDPs)? A systematic review of the survival and complication rates. Part I: Single crowns (SCs). Dent Mater. 2015;31(6):603-623. doi:10.1016/j.dental.2015.02.011
18. Pjetursson BE, Sailer I, Zwahlen M, Hämmerle CHF. A systematic review of the survival and complication rates of all-ceramic and metal-ceramic reconstructions after an observation period of at least 3 years. Part I: Single crowns. Clin Oral Implants Res. 2007;18(SUPPL. 3):73-85. doi:10.1111/j.1600-0501.2007.01467.x
19. Archibald JJ, Santos GC, Moraes Coelho Santos MJ. Retrospective clinical evaluation of ceramic onlays placed by dental students. J Prosthet Dent. 2018;119(5):743-748.e1. doi:10.1016/j.prosdent.2017.07.004
20. Otto T MW. Clinical performance of chairside CAD/CAM feldspathic ceramic posterior shoulder crowns and endocrowns up to 12 years. Int J Comput Dent. 2015;18(2):147-161. https://pubmed.ncbi.nlm.nih.gov/26110927/
21. Fages M, Raynal J, Tramini P, Cuisinier F, Durand J-C. Chairside Computer-

Aided Design/Computer-Aided Manufacture All-Ceramic Crown and Endocrown Restorations: A 7-Year Survival Rate Study. Int J Prosthodont. 2017;30(6):556-560. doi:10.11607/ijp.5132
22. Lin CL, Chang YH, Chang CY, Pai CA, Huang SF. Finite element and Weibull analyses to estimate failure risks in the ceramic endocrown and classical crown for endodontically treated maxillary premolar. Eur J Oral Sci. 2010;118(1):87-93. doi:10.1111/j.1600-0722.2009.00704.x
23. de Carvalho MA, Lazari PC, Gresnigt M, Del Bel Cury AA, Magne P. Current options concerning the endodontically-treated teeth restoration with the adhesive approach. Braz Oral Res. 2018;32:147-158. doi:10.1590/1807-3107bor-2018.vol32.0074
24. Sorensen JA, Martinoff JT. Intracoronal reinforcement and coronal coverage: A study of endodontically treated teeth. J Prosthet Dent. 1984;51(6):780-784. doi:10.1016/0022-3913(84)90376-7
25. Aquilino SA CD. Relationship between crown placement and the survival of endodontically treated teeth. J Prosthet Dent. 2002;87(3):256-263. doi:10.1067/mpr.2002.122014
26. Nandini S. Indirect resin composites. J Conserv Dent. 2010;13(4):184-194. doi:https://dx.doi.org/10.4103%2F0972-0707.73377
27. 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.
28. Chrepa V, Konstantinidis I, Kotsakis GA, Mitsias ME. The survival of indirect composite resin onlays for the restoration of root filled teeth: A retrospective medium-term study. Int Endod J. 2014;47(10):967-973. doi:10.1111/iej.12242
29. Belli S, Eraslan O, Eskitascioglu G. Direct Restoration of Endodontically Treated Teeth: a Brief Summary of Materials and Techniques. Curr Oral Heal Reports. 2015;2(4):182-189. doi:10.1007/s40496-015-0068-5
30. Dammaschke T, Nykiel K, Sagheri D, Schäfer E. Influence of coronal restorations on the fracture resistance of root canal-treated premolar and molar teeth: A retrospective study. Aust Endod J. 2013;39(2):48-56. doi:10.1111/aej.12002
31. Lynch CD, Burke FM, Ní Ríordáin R HA. The influence of coronal restoration type on the survival of endodontically treated teeth. Eur J Prosthodont Restor Dent. 2004;12(4):171-176. https://pubmed.ncbi.nlm.nih.gov/15691191/
32. Touré B, Faye B, Kane AW, Lo CM, Niang B, Boucher Y. Analysis of reasons for extraction of endodontically treated teeth: A prospective study. J Endod. 2011;37(11):1512-1515. doi:10.1016/j.joen.2011.07.002
33. Sequeira-Byron P, Fedorowicz Z, Carter B, Nasser M, Alrowaili EF. Single crowns versus conventional fillings for the restoration of root-filled teeth. Cochrane Database Syst Rev. 2015;2015(9). doi:10.1002/14651858.CD009109.pub3
34. Shu X, Mai Q-Q, Blatz M, Price R, Wang X-D, Zhao K. Direct and Indirect Restorations for Endodontically Treated Teeth: A Systematic Review and Meta-analysis, IAAD 2017 Consensus Conference Paper. J Adhes Dent. 2018;20(3):183-194. doi:10.3290/j.jad.a40762
35. Frankenberger R, Zeilinger I, Krech M, et al. Stability of endodontically treated teeth with differently invasive restorations: Adhesive vs. non-adhesive cusp stabilization. Dent Mater. 2015;31(11):1312-1320.

doi:10.1016/j.dental.2015.08.160
36. Aboobaker S, Nair BG, Gopal R, Jituri S, Veetil FRP. Effect of intra-orifice barriers on the fracture resistance of endodontically treated teeth – An ex-vivo study. J Clin Diagnostic Res. 2015;9(2):ZC17-ZC20. doi:10.7860/JCDR/2015/11609.5552
37. RF M, SK I, O de OF, J M. Fracture resistance of weakened teeth restored with condensable resin with and without cusp coverage. J Appl Oral Sci. 2009;17(3):161-165. doi:10.1590/S1678-77572009000300006
38. Plotino G, Buono L, Grande NM, Lamorgese V, Somma F. Fracture resistance of endodontically treated molars restored with extensive composite resin restorations. J Prosthet Dent. 2008;99(3):225-232. doi:10.1016/S0022-3913(08)60047-5
39. Bianchi E Silva AA méli., Ghiggi PC ristin., Mota EG onçalve., Borges GA ntoni., Burnett LH enriqu., Spohr AM ari. Influence of restorative techniques on fracture load of endodontically treated premolars. Stomatologija. 2013;15(4):123-128.
40. 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. doi:10.1016/S0099-2399(89)80191-8
41. Abu-Awwad M. A modern guide in the management of endodontically treated posterior teeth. Eur J Gen Dent. 2019;8(3):63-70. doi:10.4103/ejgd.ejgd-76-19
42. Soner Şişmanoğlu. Restoration of Endodontically Treated Teeth: A Review of Direct Restorative Approach. Heal Sci. 2020;2(1):21-40.
43. Scotti N, Rota R, Scansetti M, et al. Influence of adhesive techniques on fracture resistance of endodontically treated premolars with various residual wall thicknesses. J Prosthet Dent. 2013;110(5):376-382. doi:10.1016/j.prosdent.2013.08.001