International Journal of Applied Dental Sciences 2022; 8(1): 79-83

ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2022; 8(1): 79-83

www.oraljournal.com
Received: 13-10-2021
Accepted: 21-12-2021

Marcela Anaid De Leon Flores
Master's in Sciences Student, Universidad Autonoma de Nuevo Leon, Facultad de Odontologia, Monterrey, Nuevo Leon, Mexico

Nemesio Elizondo Garza
Professor, Universidad Autonoma de Nuevo Leon, Facultad De Odontologia, Monterrey, Nuevo Leon, Mexico

Juan Eduardo Arizpe Coronado
Professor, Universidad Autonoma de Nuevo Leon, Facultad De Odontologia, Monterrey, Nuevo Leon, Mexico

Mercedes Soledad Briceño Ancona
Professor, Universidad Veracruzana, Facultad De Odontologia, Xalapa, Veracruz

Rafael Alonso Nuñez
Professor, Universidad Veracruzana, Facultad De Odontologia, Xalapa, Veracruz

Sergio Eduardo Nakagoshi Cepeda
Professor, Universidad Veracruzana, Facultad De Odontologia, Xalapa, Veracruz

Leslie Flores Eguia
Dentistry Student, Universidad Autonoma de Nuevo Leon, Facultad De Odontologia, Monterrey, Nuevo Leon, Mexico

Juan Manuel Solis Soto
Professor, Universidad Autonoma de Nuevo Leon, Facultad De Odontologia, Monterrey, Nuevo Leon, Mexico

Corresponding Author:
Juan Manuel Solis Soto
Professor, Universidad Autonoma de Nuevo Leon, Facultad De Odontologia, Monterrey, Nuevo Leon, Mexico

Indirect ceramic overlay restorations as a minimally invasive alternative for posterior rehabilitation

Marcela Anaid De Leon Flores, Nemesio Elizondo Garza, Juan Eduardo Arizpe Coronado, Mercedes Soledad Briceño Ancona, Rafael Alonso Nuñez, Sergio Eduardo Nakagoshi Cepeda, Leslie Flores Eguia and Juan Manuel Solis Soto

DOI: https://doi.org/10.22271/oral.2022.v8.i1b.1411

Abstract
Introduction: Full coverage crowns are still the most common procedure. Indirect partial overlay restorations have been suggested as a minimally invasive alternative, preserving more healthy tooth structure while providing cusp protection.
Objective: To analyze the literature on indirect overlay posterior restorations as a minimally invasive alternative to the placement of full coverage crowns, their survival, resistance to fracture, preparation design and biomimetic considerations.
Methodology: An electronic search was carried out through PubMed (MEDLINE), Google Scholar and Cochrane Library, using the terms: "overlay", "partial crown", AND "ceramic" or "porcelain" AND "survival" or "resistance" AND "design".
Results: Overlay restorations show an acceptable medium and long-term survival rate like that of conventional full coverage crowns. The main mode of failure is ceramic fracture, followed by adhesion failure. The resistance to fracture is influenced by the physical properties of the restorative material, the cementing agent used and the design of the preparation; the latter being the most influential and characteristic factor of overlay restorations that confer biomimetic advantages superior to conventional crowns.
Conclusion: Lithium disilicate overlay restorations have a satisfactory long-term survival rate. The technique allows for minimally invasive restorations, increased resistance to fracture and prolongs the restorative life cycle of the dental organ.

Keywords: overlay, partial crown, survival, resistance, posterior, biomimetic dentistry, ceramic

1. Introduction
As life expectancy has been increasing [1], as well as the number of natural teeth maintained in the mouth at an older age, and as dental caries and non-carious lesions resulting from parafunction are among the main problems worldwide, the clinical use of posterior indirect restorations is very frequent [2, 3, 4]. The preparation of the restoration and selection of the appropriate material are important criteria to consider in order to prolong its time in the oral cavity.
Today, minimally invasive dentistry has become a field of great interest in modern restorative dentistry. The development and improvement of adhesive materials and techniques has shifted the focus from conventional, mechanical retention-oriented practice to a biological, adhesive and biomimetic one [5]. Among these new materials, lithium disilicate is one of the most promising, thanks to its high mechanical strength, with satisfactory medium and long-term survival, and excellent optical properties. It allows the use of the material not only for the esthetic anterior sector, but also as monolithic inlays in posterior teeth, making it the gold standard material for indirect restorations in the posterior sector. In addition, thanks to its biomechanical characteristics, it allows working in minimum thickness values of 0.7 mm in the posterior sector, without affecting its strength [6, 7, 8]. Simultaneously to the improvements in ceramics, there have been advances in bonding and luting agents, as well as techniques,

which have allowed the long-lasting success of adhesive restorations, being equal or greater than those of mechanical retention [9]. However, despite the advances in technology and ceramic materials, full-coverage crowns are still the most common fixed prosthodontic treatment in the posterior sector [10].

The technique of preparing conventional crowns as posterior indirect restorations leads to significant loss of tooth structure. Other concerns associated with crown preparation include the post-prosthetic need for endodontic therapy, tooth weakening, root fracture and, ultimately, the need for extraction. In contrast, indirect partial coverage restorations can offer a minimally invasive treatment procedure with reliable occlusal schemes.

Cusp coverage refers to covering all posterior tooth cusps with direct or indirect restorative material [11]. The choice to place an overlay ceramic restoration is due to the need to protect and strengthen the remaining tooth structure with a cusp coverage while trying to avoid a conventional crown. Generally, if the cusp thickness of the vital tooth is <2 mm, a cuspid covering is suggested. For non-vital posterior teeth, the thickness limit is 3 mm [2]. Among its main indications are: cuspid coverage of endodontically treated teeth; wide cavities with thin cusps; for the management of teeth prone to fracture due to loss of tooth structure; restoration of a large occlusal surface compromised by wear and/or erosion; and for cases of complete adhesive rehabilitation with the need to restore the vertical dimension [12]. Treatment of cracked tooth syndrome is another possible indication for cuspid coverage. The overlay restoration has proven to be an effective treatment to eliminate the symptoms of cracked tooth syndrome without the need for endodontic treatment in most cases [2].

Indirect partial overlay restorations have been suggested as an alternative to full crowns because they preserve a healthier tooth structure while providing cuspid protection. However, a comparison between these types of restorations with respect to their survival rate and associated complications has not been thoroughly evaluated. A detailed analysis of the longevity of ceramic overlay restorations is needed, as it will further confirm the suitability of this conservative option. Therefore, the aim of this study is to review the existing literature evaluating the performance of overlay restorations as a minimally invasive alternative to full coverage posterior crowns, particularly their survival, fracture resistance, preparation design and biomimetic considerations.

2. Materials and methods

Articles on the subject published through the PubMed, SCOPUS and Google Scholar databases were analyzed, with emphasis on the last 5 years. The quality of the articles was evaluated using PRISMA guidelines, i.e., identification, review, choice and inclusion. The quality of the reviews was assessed using the measurement tool for evaluating systematic reviews (AMSTAR-2). The search was performed using Boolean logical operators AND, OR and NOT. It was realized with the words "restorations", "minimally invasive", "survival", "fracture resistance", "preparation design", "biomimetic considerations". The keywords were used individually, as well as each of them related to each other.

3. Results & Discussion

3.1 Survival

Restoration survival rate is described as the percentage of restorations in situ during a specific observation period [13].

Medium- and long-term studies are consistent in confirming that ceramic overlay restorations have an acceptable survival in both cases exceeding 90% [3, 14, 15, 16]. Malament *et al*. indicate in their study a survival rate of 96.49% for 16.9 years, without finding a significant difference with the survival rate of conventional full-coverage crowns [17]. The most frequently reported failure pattern is fracture of the ceramic and/or the tooth (76.2%), followed by decementation (42.9%) and, lastly, due to caries leakage (28.6%) [3]. Some studies attribute a higher risk of failure if the restored tooth is not vital and the patient exhibits parafunctional habits such as bruxism. However, it is difficult to know whether ceramic fracture is directly due to bruxism or alternative explanations, such as the material used, preparation design and ceramic thickness [18, 19]. Full-coverage restorations show a slightly higher survival rate of 96.75% than partial-coverage restorations with a survival rate of 95.27%. Although the difference is not statistically significant, it provides scientific evidence for using partial coverage restorations in posterior teeth, since a greater amount of tooth tissue is preserved.

3.2 Fracture Resistance

Fracture resistance is influenced by the physical properties of the restorative material, the luting agent used, and the preparation design [18]. Ceramic materials have evolved dramatically over the past 2 decades. However, there are still beliefs to avoid the use of lithium disilicate in the posterior dentition because of the high occlusal loads that could lead to premature fractures. Nevertheless, studies have shown that lithium disilicate adhesive overlay restorations have adequate mechanical behavior under load [2, 4, 7, 10, 17, 19, 20, 21, 22, 23, 24, 25]. Some authors argue that increasing the thickness of the material is one of the ways to increase its strength, however, this means increased removal of hard tissue, which is sometimes counterproductive. Furthermore, current evidence supports that reducing the thickness of lithium disilicate to 1 mm does not affect its strength and warrants the use of minimally invasive preparations [6, 26]. According to a study conducted this year, restorations with thickness <1 mm and ≥1 mm performed similarly for 16.9 years [17].

Overlay-type restorations are adhesively cemented, which not only protects the restorative material, but also reinforces the hard tissue of the tooth organ [2]. The resin cements used as cementing agents are elastic materials and tend to deform, absorbing the stress or strain generated in the restoration. However, cement polymerization shrinkage remains one of the major problems in indirect restorative dentistry, as it generates stresses that can form gaps at the adhesive interface, causing decreased support of the restoration and diminished bond strength with the ceramic [18, 25, 27, 28, 29]. Polymerization shrinkage is affected by several factors, such as resin cement characteristics, cavity configuration factor (C-factor), preparation geometry, cement thickness, and adhesive substrate [29, 30]. Therefore, cement volume is important, in fact, it can increase shrinkage stress, regardless of the decreased C-factor. Although there is no consensus on the optimal cement spacing, a spacing between 50-100 µm has shown good performance [28].

On the other hand, the design of full-coverage crowns is focused more on their mechanical and frictional retention. Unfortunately, these retentive design features result in increased stresses in both the ceramic and the bond (C-factor), as well as increased stress in the supporting tooth structure that can lead to less favorable failure modes. A flat surface results in a lower C-factor, which reduces the polymerization stress of the cementing agent compared to a cavity

preparation with a complex configuration [18, 19, 28]. Geometry, sudden transitions, steep axial walls, edges and corners concentrate stress and decrease the fracture toughness of glass-ceramic materials [5]. According to some studies, increasing the geometric complexity of the preparation design from an overlay-type restoration to a full-coverage crown decreases fracture toughness [2, 4, 5, 10, 19]. Also, higher stress concentration is observed the more axial walls prepared [4, 19].
The non-retentive design of overlay restorations decreases the stress created in the ceramic and underlying tooth during functional loading. As they are purely adhesive restorations with simple, flat preparations, they allow better absorption of forces and reduction of stresses, offering greater resistance to fracture than full-coverage crowns.

3.3 Preparation Design

A full-coverage crown preparation removes approximately 70% to 75% of the tooth structure, whereas preparations for overlay or onlay restorations remove only 32% to 47% [31]. In addition, the conventional crown often involves the creation of a subgingival preparation margin and thus leaves the crown-tooth seal line in a significantly less hygienic area [32]. This results in a greater likelihood of carious lesion formation, as well as a more subgingival future preparation, with possible need for additional treatments such as crown lengthening, in case of leakage.
Traditionally, preparation designs for posterior indirect ceramic restorations have been based on conventional designs, with greater occlusal reduction, resulting in significant removal of tooth structure, and consequently greater cusp stress and flexure, which reduces the fracture resistance of the tooth [19]. These conventional principles suggest a cavity with a 6 to 10-degree divergent wall, rounded internal angles, enamel finish with sharp, non-beveled margins, smooth, well-defined walls, and a simple overall design without regard to the natural morphostructural and histoanatomical geometry of the tooth organ. They were derived from preparations intended for indirect restorations that were not adhesively but mechanically retained by placing shoulders, occlusal grooves, and pins, which could expose healthy dentin with significant loss of structural tissue [33].
The new principles of cavity preparation are based on morphological considerations in terms of geometry and structure. Bazos and Magne proposed a bioemulation model, with preparation based on tooth morphology, in order to improve bond quality by optimizing enamel prism cutting and increasing the available enamel surface area; minimize dentin exposure; maximize hard tissue preservation; improve stress distribution, increasing its strength; and optimize esthetic integration [34]. In general, it is recommended that preparations have a simple geometry, with a uniform occlusal reduction (minimum 1 to 1. 5 mm) for homogeneous force distribution, avoiding sharp edges and corners as well as tractional stresses. As far as possible, convert them into compressive stresses through preparation design, have smooth transitions, have as large a contact surface of the restoration as possible and that the preparation margins end in enamel to achieve a more stable bond and ensure an adequate marginal seal [2, 18, 28]. Enamel prisms should be cut obliquely, as they offer a higher bond strength than when cut horizontally and the forces will be transmitted towards the center of the tooth and not at the periphery [18].
In chronological order, Veneziani suggests a sequence of preparation starting with the preparation of the interproximal box, followed by the reduction of the occlusal surface, following the anatomy of the cusps, and finally, the definition of the margins of the axial walls, depending on whether it is an upper or lower jaw tooth [33]. Federico Ferraris describes three types of preparations that can be applied according to the esthetic and functional requirement: preparation of the cusps following the inclination of the occlusal plane with horizontal margins ("Butt joint"), beveled preparation; with a bevel at 45˚ of 1-1.5 mm long on the vestibular or palatal side, and preparation with a 1 mm thick rounded termination line. According to a study this year, the fracture toughness of all preparation designs withstands and even exceeds the load of masticatory forces; however, the 360-degree beveled preparation provides greater strength than the other preparation types, possibly because of the preservation of enamel throughout the periphery, with the presence of more interaxial dentin [10]. Preservation of marginal ridges adds support and strength to overlay-type restorations.
The preparation design is related to the final strength of the restoration. Simple, flat geometry, based on tooth morphology, without stress-generating transitions and edges, decreases the C-factor, improves load distribution during mastication, improves the strength of the restoration and provides greater longevity of the restoration.

3.4 Biomimetic Considerations

One of the reasons biomimetic dentistry is successful is due to the preservation of the most important structures of the tooth organ; preserving the areas that biologically offer the most support. The response to chewing forces and stress distribution within the tooth organ is related to its structure. The enamel, together with the amelodentin junction, act as stress distributors, transferring the occlusal forces towards the longitudinal axis of the tooth. Important concepts to consider in ceramic design and the maintenance of long-term health of teeth, both structurally and biologically, are those of the "compression dome" and the "bio-rim" [35].
In biomimetic dentistry, the compression dome refers to the tooth enamel structure above the line of maximum contour (tooth equator) that receives primarily compressive forces. The tooth structure from the maximum contour line to the cemento-enamel junction (approx. 2 mm) that supports the compression dome is referred to as the bio-rim. This region of the tooth bears the greatest amount of tensile forces during mastication [35]. The dentin-enamel complex and dentin in this region are important structures that have been shown to dampen and mitigate damaging tensile forces [36]. This is because the amelodentin junction is an elastic zone of approximately 200 µm, composed of a higher collagen content than dentin (50% vs. 30%), which allows the transfer of vertical forces received by the enamel, converting them into horizontal forces and mitigating them towards the dentin and center of the tooth [37]. According to the Moiré pattern analysis, stress and tensile forces are greatest in the cervical region and outer edge of the tooth, and these are mitigated and dissipated through the dentin-enamel complex [37, 38, 39]. The enamel in this region is better able to survive due to its complex microstructure, the presence of underlying thick elastic dentin and its gradual reinforced interaction with the dentin-enamel complex.
Studies have shown that, under stress and strain, restorations fail first at the cervical margin, generating microleakage, and then the rest of the system fails [40, 41]. The cervical margins of restorations are some of the weakest interfaces, especially when they are retentive and cemented and unbonded, where there is nothing to prevent the margin from microscopically

flexing, creating microleakage of oral fluids into the cement interface during mastication, and consequently, the formation of secondary caries and/or decementation of the restoration. The preservation of enamel at the periphery of the preparation of overlay restorations helps resist deformation, while the dentin-enamel complex dissipates forces, increasing resistance to fracture. Unlike all-ceramic, full-coverage, retentive crowns, the amount of enamel and dentin-enamel complex is diminished by their preparation design below the line of maximum contour; they no longer reinforce and stabilize the tooth to deforming loads, the much narrower and weaker dentin is less able to prevent cracks from propagating into the root, which may result in the need for endodontic treatment and a guarded future prognosis [5].

Ceramics and glasses are very resistant to compression and very weak to tensile forces. Therefore, in addition to preparation geometry and design, it is important to preserve the bio-rim. The preparation of overlay-type restorations preserves this structure, helping to support the restoration and mitigate the tractional forces generated during mastication, provides an interface between the different moduli of elasticity between the ceramic and dentin, and maintains pulp health by leaving the preparation and cervical margin of the restoration away from the dental pulp.

4. Conclusions

Based on current scientific evidence, overlay restorations should be considered the treatment of first choice for posterior rehabilitation. The conventional crown preparation technique leads to a significant loss of tooth structure. A conservative approach will ensure a more favorable prognosis due to the preservation of hard tissues, which is essential for the longevity of the restoration and the tooth organ. In addition, they present many other advantages as a biomimetic alternative to the conventional crown: they work in harmony with the natural biomechanics of the tooth, help extend the restorative life cycle of the tooth and maximize the fracture resistance of ceramic materials, thanks to the preparation design and bonding technique.

References

1. WHO. World health statistics 2020: monitoring health for the SDGs, sustainable development goals. Geneva: World Health Organization. 2020.
2. Ferraris F. Posterior indirect adhesive restorations (PIAR): preparation designs and adhesthetics clinical protocol. Int J Esthet Dent. 2017;12(4):482-502.
3. Abduo J, Sambrook RJ. Longevity of ceramic onlays: A systematic review. J Esthet Restor Dent. 2018 May;30(3):193-215.
4. Huang X, Zou L, Yao R, Wu S, Li Y. Effect of preparation design on the fracture behavior of ceramic occlusal veneers in maxillary premolars. J Dent. 2020 Jun;97:103346.
5. Schiffenhaus S. The Nonretentive Ceramic Overlay. A biomimetic alternative to the full coverage crown. Inside Dentistry. 2021 August;17(8):24-31.
6. Luciano M, Francesca Z, Michela S, Tommaso M, Massimo A. Lithium disilicate posterior overlays: clinical and biomechanical features. Clin Oral Investig. 2020 Feb;24(2):841-848.
7. Yan J, Kaizer MR, Zhang Y. Load-bearing capacity of lithium disilicate and ultra-translucent zirconias. J Mech Behav Biomed Mater. 2018;88:170-175.
8. Ma L, Guess PC, Zhang Y. Load-bearing properties of minimal-invasive monolithic lithium disilicate and zirconia occlusal onlays: finite element and theoretical analyses. Dent Mater. 2013;29(7):742-751.
9. Perdigão J, Araujo E, Ramos RQ, Gomes G, Pizzolotto L. Adhesive dentistry: Current concepts and clinical considerations. J Esthet Restor Dent. 2021 Jan;33(1):51-68.
10. Ferraris F, Sammarco E, Romano G, Cincera S, Marchesi G. Comparison of posterior indirect adhesive restorations (PIAR) with different preparation designs according to the adhesthetics classification. Part 1: Effects on the fracture resistance. Int. J Esthet Dent. 2021 May 10;16(2):144-167.
11. Abu-Awwad M. Dentists' decisions regarding the need for cuspal coverage for endodontically treated and vital posterior teeth. Clin. Exp. Dent Res. 2019 Apr 15;5(4):326-335.
12. Hegde VR, Joshi SR, Hattarki SA, Jain A. Morphology-driven preparation technique for posterior indirect bonded restorations. J Conserv Dent. 2021 Jan-Feb;24(1):100-104.
13. Vagropoulou GI, Klifopoulou GL, Vlahou SG, Hirayama H, Michalakis K. Complications and survival rates of inlays and onlays vs complete coverage restorations: A systematic review and analysis of studies. J Oral Rehabil. 2018 Nov;45(11):903-920.
14. Archibald JJ, Santos GC Jr, Moraes Coelho Santos MJ. Retrospective clinical evaluation of ceramic onlays placed by dental students. J Prosthet Dent. 2018 May;119(5):743-748.
15. Lu T, Peng L, Xiong F, Lin XY, Zhang P, Lin ZT, Wu BL. A 3-year clinical evaluation of endodontically treated posterior teeth restored with two different materials using the CEREC AC chair-side system. J Prosthet Dent. 2018 Mar;119(3):363-368.
16. Baader K, Hiller KA, Buchalla W, Schmalz G, Federlin M. Self-adhesive Luting of Partial Ceramic Crowns: Selective Enamel Etching Leads to Higher Survival after 6.5 Years *In Vivo*. J Adhes Dent. 2016;18(1):69-79.
17. Malament KA, Margvelashvili-Malament M, Natto ZS, Thompson V, Rekow D, Att W. Comparison of 16.9-year survival of pressed acid etched e.max lithium disilicate glass-ceramic complete and partial coverage restorations in posterior teeth: Performance and outcomes as a function of tooth position, age, sex, and thickness of ceramic material. J Prosthet Dent. 2021 Oct;126(4):533-545.
18. Politano G, Van Meerbeek B, Peumans M. Nonretentive Bonded Ceramic Partial Crowns: Concept and Simplified Protocol for Long-lasting Dental Restorations. J Adhes Dent. 2018;20(6):495-510.
19. Vianna ALSV, Prado CJD, Bicalho AA, Pereira RADS, Neves FDD, Soares CJ. Effect of cavity preparation design and ceramic type on the stress distribution, strain and fracture resistance of CAD/CAM onlays in molars. J Appl Oral Sci. 2018;26:e20180004.
20. Falahchai M, Babaee Hemmati Y, Neshandar Asli H, Rezaei E. Effect of Tooth Preparation Design on Fracture Resistance of Zirconia-Reinforced Lithium Silicate Overlays. J Prosthodont. 2020 Aug;29(7):617-622.
21. Falahchai M, Babaee Hemmati Y, Neshandar Asli H, Neshandar Asli M. Marginal adaptation of zirconia-reinforced lithium silicate overlays with different preparation designs. J Esthet Restor Dent. 2020 Dec;32(8):823-830.

22. Mobilio N, Fasiol A, Catapano S. Survival Rates of Lithium Disilicate Single Restorations: A Retrospective Study. Int. J Prosthodont. 2018 May/Jun;31(3):283-286.
23. Malament KA, Margvelashvili-Malament M, Natto ZS, Thompson V, Rekow D, Att W. 10.9-year survival of pressed acid etched monolithic e-max lithium disilicate glass-ceramic partial coverage restorations: Performance and outcomes as a function of tooth position, age, sex, and the type of partial coverage restoration (inlay or onlay). J Prosthet Dent. 2021 Oct;126(4):523-532.
24. Edelhoff D, Güth JF, Erdelt K, Brix O, Liebermann A. Clinical performance of occlusal onlays made of lithium disilicate ceramic in patients with severe tooth wear up to 11 years. Dent Mater. 2019 Sep;35(9):1319-1330.
25. Tribst JPM, Dal Piva AMO, Penteado MM, Borges ALS, Bottino MA. Influence of ceramic material, thickness of restoration and cement layer on stress distribution of occlusal veneers. Braz Oral Res. 2018 Nov 29;32:e118.
26. Abu-Izze FO, Ramos GF, Borges ALS, Anami LC, Bottino MA. Fatigue behavior of ultrafine tabletop ceramic restorations. Dent Mater. 2018 Sep;34(9):1401-1409.
27. Rojpaibool T, Leevailoj C. Fracture resistance of lithium disilicate ceramics bonded to enamel or dentin using different resin cement types and film thicknesses. J Prosthodont. 2017;26(2):141-149.
28. de Andrade GS, Pinto ABA, Tribst JPM, Chun EP, Borges ALS, de Siqueira Ferreira Anzaloni Saavedra G. Does overlay preparation design affect polymerization shrinkage stress distribution? A 3D FEA study. Comput Methods Biomech Biomed Engin. 2021 Jul;24(9):1026-1034.
29. Fu J, Aregawi WA, Fok ASL. Mechanical manifestation of the C-factor in relation to photopolymerization of dental resin composites. Dent Mater. 2020 Aug;36(8):1108-1114.
30. Ausiello P, Ciaramella S, De Benedictis A, Lanzotti A, Tribst JPM, Watts DC. The use of different adhesive filling material and mass combinations to restore class II cavities under loading and shrinkage effects: a 3D-FEA. Comput Methods Biomech Biomed Engin. 2021 Apr;24(5):485-495.
31. Weber AR, Yilmaz B, Brägger U, Schimmel M, Abou-Ayash S. Relative amount of tooth structure removal in different partial- and full-crown preparation designs. Int J Prosthodont. 2021 May 17.
32. Atlas A, Grandini S, Martignoni M. Evidence-based treatment planning for the restoration of endodontically treated single teeth: importance of coronal seal, post vs no post, and indirect vs direct restoration. Quintessence Int. 2019;50(10):772-781.
33. Veneziani M. Posterior indirect adhesive restorations: updated indications and the Morphology Driven Preparation Technique. Int. J Esthet Dent. 2017;12(2):204-230.
34. Bazos P, Magne P. Bio-emulation: Biomimetically emulating nature utilizing a histo-anatomic approach; structural analysis. Eur J Esthet Dent. 2011 Spring;6(1):8-19.
35. Milicich G. The compression dome concept: the restorative implications. Gen Dent. 2017 Sep-Oct;65(5):55-60.
36. Thompson VP. The tooth: An analogue for biomimetic materials design and processing. Dent Mater. 2020 Jan;36(1):25-42.
37. Milicich G, Rainey J. Clinical presentations of stress distribution in teeth and the significance in operative dentistry. Pract Periodont Aesthet Dent. 2000;12(7):695-700.
38. Wang RZ, Weiner S. Strain-structure relations in human teeth using Moiré fringes. J Biomech. 1998 Feb;31(2):135-41.
39. Wang Z, Wang K, Xu W, Gong X, Zhang F. Mapping the mechanical gradient of human dentin-enamel-junction at different intratooth locations. Dent Mater. 2018 Mar;34(3):376-388.
40. Lazari PC, de Carvalho MA, Del Bel Cury AA, Magne P. Survival of extensively damaged endodontically treated incisors restored with different types of posts-and-core foundation restoration material. J Prosthet Dent. 2018;119(5):769-776.
41. Freeman MA, Nicholls JI, Kydd WL, Harrington GW. Leakage associated with load fatigue-induced preliminary failure of full crowns placed over three different post and core systems. J Endod. 1998;24(1):26-32.