

Atendendo a solicitação do(a) autor(a),
o texto completo desta tese/dissertação
será disponibilizado somente a partir de
06/06/2025.

At the author's request, the full text of
this thesis/dissertation will not be
available until Jun 06, 2025.



UNIVERSIDADE ESTADUAL PAULISTA
"JÚLIO DE MESQUITA FILHO"
Campus de São José dos Campos
Instituto de Ciência e Tecnologia

AMIR MOHIDIN DEMACHKIA

**RESTAURAÇÕES *ENDOCROWN* EM PRÉ-MOLARES:
influência das paredes remanescentes da estrutura dentária e
materiais restauradores na resistência à fadiga**

***ENDOCROWN RESTORATIONS IN PREMOLARS: influence of
remaining axial walls of tooth structure and restorative materials on
fatigue resistance***

2023

AMIR MOHIDIN DEMASCHKIA

**RESTAURAÇÕES *ENDOCROWN* EM PRÉ-MOLARES:
influência das paredes remanescentes da estrutura dentária e
materiais restauradores na resistência à fadiga**

***ENDOCROWN RESTORATIONS IN PREMOLARS: influence of
remaining axial walls of tooth structure and restorative materials on
fatigue resistance***

Tese apresentada ao Instituto de Ciência e Tecnologia, Universidade Estadual Paulista (Unesp), Campus de São José dos Campos, como parte dos requisitos para obtenção do título de DOUTOR, pelo Programa de Pós-Graduação em ODONTOLOGIA RESTAURADORA.

Área: Prótese Dentária. Linha de pesquisa: Desempenho de materiais reabilitadores protéticos.

Orientadora: Pesq. II. Dra. Renata Marques Marinho de Melo

Coorientador: Prof. Dr. João Paulo Mendes Tribst

São José dos Campos

2023

Instituto de Ciência e Tecnologia [internet]. Normalização de tese e dissertação [acesso em 2023]. Disponível em <http://www.ict.unesp.br/biblioteca/normalizacao>

Apresentação gráfica e normalização de acordo com as normas estabelecidas pelo Serviço de Normalização de Documentos da Seção Técnica de Referência e Atendimento ao Usuário e Documentação (STRAUD).

Demachkia, Amir Mohidin

Restaurações endocrown em pré-molares: influência das paredes remanescentes da estrutura dentária e materiais restauradores na resistência à fadiga / Amir Mohidin Demaschkia. - São José dos Campos : [s.n.], 2023.

Tese (Doutorado em Odontologia Restauradora) - Pós-Graduação em Odontologia Restauradora - Universidade Estadual Paulista (Unesp), Instituto de Ciência e Tecnologia, São José dos Campos, 2023.

Orientador: Renata Marques Marinho de Melo

Coorientador: João Paulo Mendes Tribst

1. Cerâmicas. 2. CAD/CAM. 3. Fadiga. 4. Falha de restaurações dentárias . 5. Análise de elementos finitos. I. Melo, Renata Marques Marinho de, orient. II. Tribst, João Paulo Mendes, coorient. III. Universidade Estadual Paulista (Unesp), Instituto de Ciência e Tecnologia, São José dos Campos. IV. Universidade Estadual Paulista 'Júlio de Mesquita Filho' - Unesp. V. Universidade Estadual Paulista (Unesp). VI. Título.

BANCA EXAMINADORA

Profa. Dra. Renata Marques de Melo Marinho (Orientadora)

Universidade Estadual Paulista (Unesp)

Instituto de Ciência e Tecnologia

Campus de São José dos Campos

Prof. Dr. Lafayette Nogueira Júnior

Universidade Estadual Paulista (Unesp)

Instituto de Ciência e Tecnologia

Campus de São José dos Campos

Prof. Dr. Cesar Rogério Pucci

Universidade Estadual Paulista (Unesp)

Instituto de Ciência e Tecnologia

Campus de São José dos Campos

Profa. Dra. Lais Regine da Silva Concilio

Universidade de Taubaté (Unitau)

Profa. Dra. Camila da Silva Rodrigues

Universidade Federal de Pelotas

São José dos Campos 06 de junho de 2023

DEDICATÓRIA

Á Deus, por todas as bênçãos incontáveis e por me conceder a capacidade e paciência para alcançar meus objetivos na hora certa.

Eu dedico este trabalho ao meu **Pai**, pelo apoio infinito. Sua dedicação e jornada têm sido minha grande inspiração.

Eu dedico este trabalho à minha **Mãe**, pelo esforço de cuidar e ensinar a mim e meus irmãos da melhor maneira, e por dar sem limites. Eu te amo.

Eu dedico este trabalho aos meus irmãos **Hala** e **Rida**, Sou eternamente grato a Deus por me dar irmãos tão perfeitos como vocês. Sua presença me faz sentir mais seguro nesta vida.

AGRADECIMENTO

À minha orientadora, Profa. Renata Marques de Melo, a primeira pessoa que conheci no Brasil e que me deu a oportunidade de fazer doutorado. Obrigado por acreditar no meu potencial, e por ensinar-me a fazer pesquisa e amar o que estou fazendo. Sua paixão pela educação e pela pesquisa é contagiante. Sou extremamente grato e orgulhoso de ser seu aluno.

Ao meu coorientador, Prof. João Paulo Mendes Tribst, pela orientação e por resolver as dificuldades que enfrentei durante este trabalho. Seu profundo conhecimento na área foi fundamental para o desenvolvimento deste projeto.

Ao Prof. Tit. Marco Antonio Bottino, por todos os esforços ao longo de anos para tornar o programa de pós-graduação o que é hoje. Sua dedicação incansável e comprometida foi fundamental para o crescimento e excelência do programa. Além disso, agradeço por todas as experiências valiosas e o conhecimento enriquecedor que nos transmitiu ao longo desta jornada acadêmica. Sua generosidade em compartilhar conhecimentos e experiências tem sido inestimável para todos nós.

Ao Prof. Assoc. Alexandre Luiz Souto Borges, por todos os esforços na coordenação do programa de pós-graduação e por nunca poupar esforços para superar as dificuldades enfrentando os alunos durante a jornada acadêmica. Sua dedicação exemplar tem sido fundamental para o sucesso e crescimento do programa. Além disso, agradeço profundamente pela sua contribuição neste trabalho específico.

Ao Prof. Assoc. Lafayette Nogueira, pela amizade e por compartilhar sua sabedoria e experiência na clínica de sexta-feira e dentadura. Sua orientação e conhecimento têm sido inestimáveis para o meu crescimento profissional.

Ao Prof. Assoc. Guilherme de Siqueira Ferreira Saavedra, pela amizade e por compartilhar seu conhecimento na odontologia digital. Aprendi muito de você.

Aos professores do Departamento de Materiais Odontológicos e Prótese, em especial aos professores: Prof. Dr. Rodrigo Máximo, Prof. Dr. João Mauricio, Prof. Assoc. Tarcísio. Prof. Assoc. Tango. Prof. Dr. Osvaldo Daniel Andreatta Filho.

Ao Prof. Assoc. Luis Felipe Valandro, pela ajuda, compartilhar conhecimento e disponibilizar o uso da máquina de fadiga.

Ao Hilton Riquieri, pela ajuda na parte laboratorial, especialmente na fresagem de bolachas de zircônia.

Aos colegas e amigos de pós-graduação, obrigado por ajuda e bom convívio: Lucas tanaka, Laura Calavache, Jadson Domingues, Larissa Barreto, Larissa mendes, Elisa Aboucauch, Joyce Rodrigues, Joyce Roma, Illiam Simoes, Génesis alfonzo, Juliana Silva, Jonas Rodrigus, Luigi Sichi, Alini Carvalho, Amanda Ribiero, Camila Rodrigous, Bianca tanide, Clarice Sabino, Talitab Queiroz, Rita Rodriguez, Rossana gaudio, Natalia Rossi, Michelle de Sá, Ana Beatriz Gomes, Ellen Randoli, Raquel Coutinho, Fernanda Pierre, Guilherme Scalzer, Guilherme Schmitt, Mateus Grandge, Elisa Kukulka, Stefany Couto, Laís Landim, Caique Casarini, Nathalia Ramos.

Ao meu grande amigo, Amjad Abu Hassna, meu conterrâneo que me recebeu e ajudou aqui desde o primeiro dia. Sua jornada bem-sucedida na UNESP abriu o caminho para mim e vai abrir para quem vai chegar no futuro. Suas palavras de encorajamento e seu apoio incondicional me motivaram a enfrentar cada desafio com determinação e confiança. Nossa amizade será para sempre.

Ao meu amigo, Manasses, por toda a ajuda, companheirismo no laboratório, dedicação incansável e colaboração excepcional nos projetos. Sua presença e apoio têm sido fundamentais na minha jornada.

A minha amiga, Ana Carolina da Silva, minha amiga perfeita, minha parceira na clínica e no laboratório, obrigado pela amizade, companheirismo e convívio.

A minha amiga, Karina Barbosa, obrigado pela amizade, convívio e ajuda neste trabalho, obrigado por ter cedido seu tempo para me ajudar e obrigado por corrigir meu português.

Aos meus amigos, Leonardo Gomes, Julio Ferraz, Lucas Tanaka obrigado pela amizade e convívio. Amigos que levarei para sempre.

Aos Flávia Assunção, Luciana Rocha e Carlos Leal, por recepção e ajuda, vivi os melhores momentos com vocês, obrigado meus queridos por fazerem parte da minha vida e por serem a razão de tantos sorrisos e gratidão.

À Universidade Estadual Paulista “Júlio de Mesquita Filho” - Unesp, na pessoa da diretora do Instituto de Ciência e Tecnologia de São José dos Campos,

pela oportunidade de fazer doutorado e todo apoio.

À Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), pela concessão da Bolsa de doutorado no período de 01/12/2020 a 31/05/2023, através processo número 888.595423/2020-00

À equipe da Biblioteca pela ajuda na elaboração deste trabalho, contribuindo com o acesso ao material bibliográfico e na orientação das normas.

SUMMARY

RESUMO.....	10
ABSTRACT	11
1 INTRODUCTION	11
2 LITERATURE REVIEW	14
2.1 Endocrown	14
2.2 Dental ceramics.....	21
2.2.1 Glass-matrix ceramic	22
2.2.3 Polycrystalline ceramic	24
2.3 Fatigue Tests	26
3 PROPOSITION	29
4 MATERIAL AND METHODS.....	30
4.1 Experimental design.....	32
4.2 Endodontic treatment	33
4.3 Tooth preparation	34
4.4 Fabrication of endocrowns	35
4.5 Bonding procedure	37
4.6 Fatigue failure load test (<i>Step-wise</i> fatigue test)	40
4.7 Failure and fractography analysis	40
4.8 Finite element analysis	41
4.9 Data analysis	43
5 RESULTS.....	44
5.1 Survival analysis	44
5.2 Failure analysis	47
5.3 Finite element analysis	51
6 DISCUSSION.....	56
7 CONCLUSIONS.....	62
REFERENCES	63

Demachkia AM. Restaurações endocrown em pré-molares: influência das paredes remanescentes da estrutura dentária e materiais restauradores na resistência à fadiga [tese]. São José dos Campos (SP): Universidade Estadual Paulista (Unesp), Instituto de Ciência e Tecnologia; 2023.

RESUMO

Este estudo teve como objetivo avaliar o efeito da estrutura dentária remanescente e dois materiais diferentes de restauração CAD/CAM no desempenho à fadiga e no modo de falha de pré-molares tratados endodonticamente restaurados por *endocrowns*. Um total de 90 pré-molares superiores foram tratados endodonticamente e divididos aleatoriamente de acordo com o número de paredes axiais remanescentes, e os materiais restauradores foram divididos em 6 grupos (n = 15); quatro paredes restantes restauradas com zircônia ultratranslúcida 5Y-PSZ (grupo Fo-Z) e dissilicato de lítio (grupo Fo-L), três paredes restantes restauradas com 5Y-PSZ (grupo Th-Z) e dissilicato de lítio (grupo Th-L) e duas paredes restantes restauradas com 5Y-PSZ (grupo Tw-Z) e dissilicato de lítio (Tw-L). As restaurações foram cimentadas adesivamente e os espécimes foram submetidos a cargas de fadiga gradual em seu longo eixo (carga inicial: 200 N, frequência: 20 Hz). Uma carga incremental de 100 N por 10.000 ciclos foi aplicada com um pistão metálico de Ø 6 mm até a falha. A carga de falha por fadiga (FFL) e o número de ciclos de falha (CFF) no momento da falha foram registrados e analisados estatisticamente por ANOVA 2 fatores e teste de Kaplan-Meier ($\alpha = 0,05$). Os espécimes fraturados foram examinados em estereomicroscópio em 8× e 25× e os modos de falha foram determinados como reparáveis ou catastróficos. FFL e CFF foram significativamente influenciados pelo material restaurador ($p < 0,05$). As restaurações de 5Y-PSZ apresentaram FFL (Fo-Z = 1487 N, Tw-Z = 1427 N, Tw-Z = 1533 N) e probabilidade de sobrevivência significativamente maiores quando comparadas com dissilicato de lítio (Fo-L = 1060 N, Th-L = 940 N, Tw-L = 1000 N). O número de paredes remanescentes não afetou o comportamento de fadiga ou modo de falha dos corpos de prova. Das restaurações de dissilicato de lítio, 51% tiveram falhas reparáveis, enquanto 95% das restaurações de zircônia ultratranslúcida 5Y-ZP tiveram falhas catastróficas. *Endocrowns* de zircônia apresentaram melhor desempenho em fadiga do que *endocrowns* de dissilicato de lítio, independentemente do número de paredes remanescentes do eixo. *Endocrowns* de pré-molares de dissilicato de lítio e 5Y-PSZ apresentaram maior FFL do que as cargas mastigatórias normais.

Palavras-chave: Cerâmicas. CAD/CAM. Fadiga. Falha de restaurações dentárias. Análise de elementos finitos.

Demachkia AM. Endocrown restorations in premolars: influence of remaining axial walls of tooth structure and restorative materials on fatigue resistance [doctorate thesis]. São José dos Campos (SP): Universidade Estadual Paulista (Unesp), Instituto de Ciência e Tecnologia; 2023.

ABSTRACT

This study aimed to evaluate the effect of the remaining tooth structure and two different CAD/CAM restoration materials on the fatigue performance and failure mode of endodontically treated premolars restored with endocrowns. A total of 90 maxillary premolars were endodontically treated and divided randomly according to the number of remaining axial walls, and the restorative materials were divided into 6 groups ($n = 15$); four remaining walls restored with ultratranslucent zirconia 5Y-PSZ (group Fo-Z) and lithium disilicate (group Fo-L), three remaining walls restored with 5Y-PSZ (group Th-Z) and lithium disilicate (Group Th-L), and two remaining walls restored with 5Y-PSZ (group Tw-Z) and lithium disilicate (Tw-L). The restorations were cemented adhesively and the specimens were subjected to stepwise fatigue loading along the long axis (initial load: 200 N, frequency: 20 Hz). An incremental step load of 100 N per 10,000 cycles was applied with a Ø6-mm metallic piston until failure. The fatigue failure load (FFL) and number of failure cycles (CFF) at the time of failure were recorded and statistically analyzed with two-way ANOVA and the Kaplan-Meier test ($\alpha = 0.05$). Fractured specimens were examined under a stereomicroscope at 8 $\times$ and 25 $\times$ and failure modes determined as repairable or catastrophic. FFL and CFF were significantly influenced by restorative material ($p < 0.05$). 5Y-PSZ endocrowns showed significantly higher FFL (Fo-Z = 1487 N, Th-Z = 1427 N, Tw-Z = 1533 N) and survival probability when compared with lithium disilicate (Fo-L = 1060 N, Th-L = 940 N, Tw-L = 1000 N). The number of remaining walls did not affect the fatigue behavior or failure mode of the specimens. Of the lithium disilicate restorations, 51% had repairable failures, while 95% of ultratranslucent zirconia 5Y-ZP restorations had catastrophic failures. Zirconia endocrowns showed better fatigue performance than lithium disilicate endocrowns, regardless of the number of remaining axis walls. Lithium disilicate and 5Y-PSZ premolar endocrowns showed higher FFL than the normal masticatory loads.

Keywords: Ceramics. CAD/CAM. Fatigue. Dental restoration failures. Finite element analysis.

1 INTRODUCTION

Endodontically treated teeth (ETTs) associated with extensive substance loss subsequent to trauma, caries, or wide access cavity preparation have a high risk of fracture (Reeh et al., 1989; Sedgley, Messer, 1992; Dietschi et al., 2008). Accordingly, any treatment of such teeth should take into account remaining tooth structure, tooth location, masticatory forces, and restorative material (Faria et al., 2011). Traditionally, the treatment for extensively damaged ETTs has been a post-and-core and cuspal coverage with a crown. However, in this type of treatment, post-space preparation of the intact coronal and intracanal tooth structure is needed, increasing the risk of root perforation and stripping or weakening of the tooth (Schwartz, Robbins, 2004; El Ghoul et al., 2019; Hassouneh et al., 2020). Therefore, extreme care should be taken during post-space preparation to avoid these risks (Kfir et al., 2020).

Contemporary dental treatment emphasizes the preservation of sound tooth structure as much as possible, even when restoring endodontically treated teeth. In this context, endocrown restorations (first described by Pissis in 1995) consisting of a monoblock indirect restoration with a crown extending from the intaglio surface that represents the core have become popular as an alternative to conventional post-and-core and crown restorations. The crown covers the coronal part to protect the remaining tooth structure, and the core occupies the pulp chamber to provide retention and stability to the restoration after bonding with adhesive while sealing the obturated canals (Pissis, 1995; Bindl, Mörmann, 1999). Endocrowns have gained reliability and popularity in the last few years because of improvements in adhesive systems and ceramic materials (Dietschi et al., 2008; El-Damanhoury et al., 2015; Fages et al., 2017; Munoz-Sanchez et al., 2021). A recent systematic review that included 41 articles (8 clinical studies, 33

in vitro studies) concluded that molar endocrown restorations can be considered an alternative to conventional crowns; however, additional studies are required for premolar endocrowns (Govare, Contrepois, 2020).

The development in computer-aided design/computer-aided manufacturing technologies (CAD/CAM) and ceramic materials has allowed the fabrication of endocrown restorations from different materials, including resin nanoceramic, lithium disilicate ceramic, hybrid ceramic, and zirconia. These materials have different microstructures, esthetic properties and moduli of elasticity, ranging from 10 GPa for composite resin blocks to 250 GPa for zirconia (Zhu et al., 2017). The fracture resistance of molar endocrowns from these materials has been studied, with conclusions that lithium disilicate and resin nanoceramic endocrowns had higher fracture resistance than zirconia-reinforced lithium disilicate or hybrid ceramic (Gresnigt et al., 2016; El Ghouli et al., 2019). In contrast, EL-Damanhoury et al. (2015) reported that resin nanoceramic endocrowns showed higher fracture resistance and a more favorable failure mode than lithium disilicate or feldspathic ceramic, but Dartora et al. (2019) reported no difference between the lithium disilicate and hybrid ceramic (El-Damanhoury et al., 2015; Dartora et al., 2019). However, studies on the biomechanical behavior of ultratranslucent yttria-stabilized zirconia when used as an endocrown to restore premolars are lacking. Translucent zirconia, mainly 4Y- and 5Y-PSZ has become more popular in recent years and, because of their lower toughness and fracture resistance, are typically indicated in similar clinical situations as lithium disilicate (Zhang, Lawn, 2018). Translucent zirconias were developed to overcome the esthetic limitation (high opacity) of 3Y-TZP zirconia by including a transparent phase. Translucency was achieved by adding 4 mol% (4Y-PSZ) or 5 mol% (5Y-PSZ) yttria, which is required to stabilize the cubic phase at room temperature. Although translucent zirconias are weaker than 3Y-TZP zirconia as the cubic phase does not undergo a stress-induced

transformation, they are indicated for use as a monolithic restoration in esthetic areas. (Pereira et al., 2018; Zhang, Lawn, 2018; Pereira et al., 2019).

Incidence of pulp involvement from extensive interproximal caries is commonly encountered, leading to endodontic treatment. In this situation, one or two proximal walls with intact buccal and lingual walls are often destroyed (Barallat et al., 2022). To our knowledge, information about the effect of missing proximal walls on the biomechanical behavior of premolars restored with endocrowns are lacking. Thus, the question remains: Does the number of remaining walls affect the fatigue behavior of the tooth/restoration complex and their failure mode?

Therefore, our study aimed to evaluate the effect of the remaining axial wall number (four, three, and two) and two CAD/CAM materials, lithium disilicate ceramic and ultratranslucent 5 mol% yttria stabilized zirconia (5Y-PSZ) on the fatigue resistance and failure mode of endodontically treated maxillary premolars restored with endocrowns. The null hypotheses of the study were that the endocrown material would have no influence on the fatigue failure load and failure mode and that the remaining walls of tooth structure would have no influence on the fatigue failure and failure mode.

7 CONCLUSIONS

Within the limitations of the present study, the following conclusions can be drawn:

- a) Ultra-translucent zirconia 5Y-PSZ endocrowns in premolars had a higher fatigue load to failure than lithium disilicate, regardless of the number of remaining axial walls.
- b) Number of remaining axial walls did not affect the fatigue failure load.
- c) Both tested materials showed acceptable survival probability, but lithium disilicate failed before zirconia restorations.
- d) The failure mode was predominantly non-repairable in 5Y-PSZ restorations.

REFERENCES

Ahmed MAA, Kern M, Mourshed B, Wille S, Chaar MS. Fracture resistance of maxillary premolars restored with different endocrown designs and materials after artificial ageing. *J Prosthodont Res.* 2022 Jan 11;66(1):141-50. doi: 10.2186/jpr.JPR_D_20_00082. Epub 2021 Jun 10. PMID: 34108294.

Aldesoki M, Bourauel C, Morsi T, El-Anwar MI, Aboelfadl AK, Elshazly TM. Biomechanical behavior of endodontically treated premolars restored with different endocrown designs: Finite element study. *J Mech Behav Biomed Mater.* 2022 Sep;133:105309. doi: 10.1016/j.jmbbm.2022.105309. Epub 2022 Jun 7. PMID: 35689987.

Amaral M, Villefort RF, Melo RM, Pereira GKR, Zhang Y, Valandro LF, et al. Fatigue limit of monolithic Y-TZP three-unit-fixed dental prostheses: Effect of grinding at the gingival zone of the connector. *J Mech Behav Biomed Mater.* 2017 Aug;72:159-62. doi: 10.1016/j.jmbbm.2017.03.002. Epub 2017 Mar 7. PMID: 28494273; PMCID: PMC5517038.

Anami LC, Lima JM, Valandro LF, Kleverlaan CJ, Feilzer AJ, Bottino MA. Fatigue Resistance of Y-TZP/Porcelain Crowns is Not Influenced by the Conditioning of the Intaglio Surface. *Oper Dent.* 2016 Jan-Feb;41(1):E1-12. doi: 10.2341/14-166-L. Epub 2015 Aug 12. PMID: 26266655.

Atash R, Arab M, Duterme H, Cetik S. Comparison of resistance to fracture between three types of permanent restorations subjected to shear force: An in vitro study. *J Indian Prosthodont Soc.* 2017 Jul-Sep;17(3):239-49. doi: 10.4103/jips.jips_24_17. PMID: 28936037; PMCID: PMC5601495.

Baldissara P, Wandscher VF, Marchionatti AME, Parisi C, Monaco C, Ciocca L. Translucency of IPS e.max and cubic zirconia monolithic crowns. *J Prosthet Dent.* 2018 Aug;120(2):269-75. doi: 10.1016/j.prosdent.2017.09.007. Epub 2018 Feb 21. PMID: 29475752.

Bankoğlu Güngör M, Turhan Bal B, Yilmaz H, Aydın C, Karakoca Nemli S. Fracture strength of CAD/CAM fabricated lithium disilicate and resin nano ceramic restorations used for endodontically treated teeth. *Dent Mater J.* 2017

Mar 31;36(2):135-41. doi: 10.4012/dmj.2016-017. Epub 2017 Jan 20. PMID: 28111383.

Barallat L, Arregui M, Fernandez-Villar S, Paniagua B, Pascual-La Rocca A. Fracture Resistance in Non-Vital Teeth: Absence of Interproximal Ferrule and Influence of Preparation Depth in CAD/CAM Endocrown Overlays-An In Vitro Study. *Materials (Basel)*. 2022 Jan 7;15(2):436. doi: 10.3390/ma15020436. PMID: 35057154; PMCID: PMC8778771.

Beier US, Dumfahrt H. Longevity of silicate ceramic restorations. *Quintessence Int*. 2014 Sep;45(8):637-44. doi: 10.3290/j.qi.a32234. PMID: 25126640.

Belleflamme MM, Geerts SO, Louwette MM, Grenade CF, Vanheusden AJ, Mainjot AK. No post-no core approach to restore severely damaged posterior teeth: An up to 10-year retrospective study of documented endocrown cases. *J Dent*. 2017 Aug;63:1-7. doi: 10.1016/j.jdent.2017.04.009. Epub 2017 Apr 27. PMID: 28456557.

Biacchi GR, Basting RT. Comparison of fracture strength of endocrowns and glass fiber post-retained conventional crowns. *Oper Dent*. 2012 Mar-Apr;37(2):130-6. doi: 10.2341/11-105-L. Epub 2011 Sep 26. PMID: 21942234.

Bindl A, Mörmann WH. Clinical evaluation of adhesively placed Cerec endocrowns after 2 years--preliminary results. *J Adhes Dent*. 1999;1(3):255-65. PMID: 11725673.

Bonfante EA, Coelho PG. A Critical Perspective on Mechanical Testing of Implants and Prostheses. *Adv Dent Res*. 2016 Mar;28(1):18-27. doi: 10.1177/0022034515624445. PMID: 26927484.

Campos TM, Ramos NC, Machado JP, Bottino MA, Souza RO, Melo RM. A new silica-infiltrated Y-TZP obtained by the sol-gel method. *J Dent*. 2016 May;48:55-61. doi: 10.1016/j.jdent.2016.03.004. Epub 2016 Mar 21. PMID: 27012859.

Chang CY, Kuo JS, 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 Sep 1;4(3):110-7. doi: 10.1016/S1991-7902(09)60016-7.

Cokic SM, Vleugels J, Van Meerbeek B, Camargo B, Willems E, Li M, et al. Mechanical properties, aging stability and translucency of speed-sintered zirconia for chairside restorations. *Dent Mater*. 2020 Jul;36(7):959-72. doi: 10.1016/j.dental.2020.04.026. Epub 2020 Jun 1. PMID: 32493658.

Dartora G, Rocha Pereira GK, Varella de Carvalho R, Zucuni CP, Valandro LF, Cesar PF, et al. Comparison of endocrowns made of lithium disilicate glass-ceramic or polymer-infiltrated ceramic networks and direct composite resin restorations: fatigue performance and stress distribution. *J Mech Behav Biomed Mater*. 2019 Dec;100:103401. doi: 10.1016/j.jmbbm.2019.103401. Epub 2019 Aug 19. PMID: 31445400.

Dartora NR, de Conto Ferreira MB, Moris ICM, Brazão EH, Spazin AO, Sousa-Neto MD, et al. Effect of Intracoronary Depth of Teeth Restored with Endocrowns on Fracture Resistance: In Vitro and 3-dimensional Finite Element Analysis. *J Endod*. 2018 Jul;44(7):1179-85. doi: 10.1016/j.joen.2018.04.008. Epub 2018 Jun 1. PMID: 29866407.

De Kuijper MCFM, Cune MS, Tromp Y, Gresnigt MMM. Cyclic loading and load to failure of lithium disilicate endocrowns: Influence of the restoration extension in the pulp chamber and the enamel outline. *J Mech Behav Biomed Mater*. 2020 May;105:103670. doi: 10.1016/j.jmbbm.2020.103670. Epub 2020 Feb 4. PMID: 32090891.

Dejak B, Młotkowski A, Langot C. Three-dimensional finite element analysis of molars with thin-walled prosthetic crowns made of various materials. *Dent Mater*. 2012 Apr;28(4):433-41. doi: 10.1016/j.dental.2011.11.019. Epub 2011 Dec 29. PMID: 22209573.

Dejak B, Młotkowski A. 3D-Finite element analysis of molars restored with endocrowns and posts during masticatory simulation. *Dent Mater*. 2013 Dec;29(12):e309-17. doi: 10.1016/j.dental.2013.09.014. Epub 2013 Oct 21. PMID: 24157244.

Dietschi D, Duc O, Krejci I, Sadan A. Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature--Part 1. Composition and micro- and macrostructure alterations. *Quintessence Int*. 2007 Oct;38(9):733-43. PMID: 17873980.

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 Feb;39(2):117-29. PMID: 18560650.

El-Damanhoury HM, Haj-Ali RN, Platt JA. Fracture resistance and microleakage of endocrowns utilizing three CAD-CAM blocks. Oper Dent. 2015 Mar-Apr;40(2):201-10. doi: 10.2341/13-143-L. Epub 2014 Sep 30. PMID: 25268039.

Einhorn M, DuVall N, Wajdowicz M, Brewster J, Roberts H. Preparation Ferrule Design Effect on Endocrown Failure Resistance. J Prosthodont. 2019 Jan;28(1):e237-e242. doi: 10.1111/jopr.12671. Epub 2017 Oct 6. PMID: 28985446.

Fages M, Raynal J, Tramini P, Cuisinier FJ, Durand JC. Chairside Computer-Aided Design/Computer-Aided Manufacture All-Ceramic Crown and Endocrown Restorations: A 7-Year Survival Rate Study. Int J Prosthodont. 2017 November/December;30(6):556–60. doi: 10.11607/ijp.5132. Epub 2017 Oct 30. PMID: 29084297.

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 Apr;55(2):69-74. doi: 10.1016/j.jpor.2010.07.003. Epub 2010 Aug 14. PMID: 20709618.

Firidinoğlu K, Toksavul S, Toman M, Sarikanat M, Nergiz I. Fracture resistance and analysis of stress distribution of implant-supported single zirconium ceramic coping combination with abutments made of different materials. J Appl Biomech. 2012 Aug;28(4):394-9. doi: 10.1123/jab.28.4.394. Epub 2011 Jul 29. PMID: 21904010.

Gold SA, Ferracane JL, da Costa J. Effect of Crystallization Firing on Marginal Gap of CAD/CAM Fabricated Lithium Disilicate Crowns. J Prosthodont. 2018 Jan;27(1):63-6. doi: 10.1111/jopr.12638. Epub 2017 May 17. PMID: 28514042.

Govare N, Contrepolis M. Endocrowns: A systematic review. J Prosthet Dent. 2020 Mar;123(3):411-418.e9. doi: 10.1016/j.prosdent.2019.04.009. Epub 2019 Jul 26. PMID: 31353111.

Gracis S, Thompson VP, Ferencz JL, Silva NR, Bonfante EA. A new classification system for all-ceramic and ceramic-like restorative materials. Int J

Prosthodont. 2015 May-Jun;28(3):227-35. doi: 10.11607/ijp.4244. PMID: 25965634.

Gresnigt MM, Özcan M, van den Houten ML, Schipper L, Cune MS. Fracture strength, failure type and Weibull characteristics of lithium disilicate and multiphase resin composite endocrowns under axial and lateral forces. *Dent Mater*. 2016 May;32(5):607-14. doi: 10.1016/j.dental.2016.01.004. Epub 2016 Feb 28. PMID: 26935018.

Guess PC, Schultheis S, Bonfante EA, Coelho PG, Ferencz JL, Silva NR. All-ceramic systems: laboratory and clinical performance. *Dent Clin North Am*. 2011 Apr;55(2):333-52, ix. doi: 10.1016/j.cden.2011.01.005. Epub 2011 Mar 3. PMID: 21473997.

Guo J, Wang Z, Li X, Sun C, Gao E, Li H. A comparison of the fracture resistances of endodontically treated mandibular premolars restored with endocrowns and glass fiber post-core retained conventional crowns. *J Adv Prosthodont*. 2016 Dec;8(6):489-93. doi: 10.4047/jap.2016.8.6.489. Epub 2016 Dec 15. PMID: 28018567; PMCID: PMC5179488.

Hamdy A. Effect of full coverage, endocrowns, onlays, inlays restorations on fracture resistance of endodontically treated molars. *J Dent Oral Hyg*. 2015;5(1):1-5.

Hassouneh L, Jum'ah AA, Ferrari M, Wood DJ. Post-fatigue fracture resistance of premolar teeth restored with endocrowns: An in vitro investigation. *J Dent*. 2020. Sep;100:103426. doi: 10.1016/j.jdent.2020.103426. Epub 2020 Jul 3. PMID: 32628987.

Hayes A, Duvall N, Wajdowicz M, Roberts H. Effect of Endocrown Pulp Chamber Extension Depth on Molar Fracture Resistance. *Oper Dent*. 2017 May/Jun;42(3):327-34. doi: 10.2341/16-097-L. PMID: 28467258.

Helal MA, Wang Z. Biomechanical Assessment of Restored Mandibular Molar by Endocrown in Comparison to a Glass Fiber Post-Retained Conventional Crown: 3D Finite Element Analysis. *J Prosthodont*. 2019 Dec;28(9):988-96. doi: 10.1111/jopr.12690. Epub 2017 Oct 25. PMID: 29067737.

Homaei E, Farhangdoost K, Tsoi JKH, Matinlinna JP, Pow EHN. Static and fatigue mechanical behavior of three dental CAD/CAM ceramics. *J Mech Behav Biomed Mater*. 2016 Jun;59:304-13. doi: 10.1016/j.jmbbm.2016.01.023. Epub 2016 Feb 2. PMID: 26896763.

Kelly JR, Benetti P. Ceramic materials in dentistry: historical evolution and current practice. *Aust Dent J*. 2011 Jun;56 Suppl 1:84-96. doi: 10.1111/j.1834-7819.2010.01299.x. PMID: 21564119.

Kelly JR, Cesar PF, Scherrer SS, Della Bona A, van Noort R, Tholey M, et al. ADM guidance-ceramics: Fatigue principles and testing. *Dent Mater*. 2017 Nov;33(11):1192-1204. doi: 10.1016/j.dental.2017.09.006. Epub 2017 Oct 7. PMID: 29017761.

Kelly JR, Denry I. Stabilized zirconia as a structural ceramic: an overview. *Dent Mater*. 2008 Mar;24(3):289-98. doi: 10.1016/j.dental.2007.05.005. Epub 2007 Jul 12. PMID: 17624420.

Kelly JR. Clinically relevant approach to failure testing of all-ceramic restorations. *J Prosthet Dent*. 1999 Jun;81(6):652-61. doi: 10.1016/s0022-3913(99)70103-4. PMID: 10347352.

Kelly JR. Dental ceramics: current thinking and trends. *Dent Clin North Am*. 2004 Apr;48(2):viii, 513-30. doi: 10.1016/j.cden.2004.01.003. PMID: 15344442
Kelly JR. Perspectives on strength. *Dent Mater*. 1995 Mar;11(2):103-10. doi: 10.1016/0109-5641(95)80043-3. PMID: 8621029.

Kfir A, Mostinsky O, Elyzur O, Hertzeanu M, Metzger Z, Pawar AM. Root canal configuration and root wall thickness of first maxillary premolars in an Israeli population. A Cone-beam computed tomography study. *Sci Rep*. 2020 Jan 16;10(1):434. doi: 10.1038/s41598-019-56957-z. PMID: 31949190; PMCID: PMC6965655.

Kwon SJ, Lawson NC, McLaren EE, Nejat AH, Burgess JO. Comparison of the mechanical properties of translucent zirconia and lithium disilicate. *J Prosthet Dent*. 2018 Jul;120(1):132-37. doi: 10.1016/j.prosdent.2017.08.004. Epub 2018 Jan 6. PMID: 29310875.

Lawson NC, Jurado CA, Huang CT, Morris GP, Burgess JO, Liu PR, et al. Effect of Surface Treatment and Cement on Fracture Load of Traditional Zirconia (3Y), Translucent Zirconia (5Y), and Lithium Disilicate Crowns. *J Prosthodont*. 2019 Jul;28(6):659-65. doi: 10.1111/jopr.13088. Epub 2019 Jun 11. PMID: 31145492; PMCID: PMC6642729.

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 Jul;29(7):742-51. doi: 10.1016/j.dental.2013.04.004. Epub 2013 May 15. PMID: 23683531; PMCID: PMC3698988.

Palamara D, Palamara JE, Tyas MJ, Messer HH. Strain patterns in cervical enamel of teeth subjected to occlusal loading. *Dent Mater.* 2000 Nov;16(6):4129. doi: 10.1016/s0109-5641(00)00036-1. PMID: 10967190

Papadogiannis DY, Lakes RS, Papadogiannis Y, Palaghias G, Helvatjoglu-Antoniades M. The effect of temperature on the viscoelastic properties of nano-hybrid composites. *Dent Mater.* 2008 Feb;24(2):257-66. doi: 10.1016/j.dental.2007.05.009. Epub 2007 Jul 20. PMID: 17640723

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 Apr;59:54-61. doi: 10.1016/j.jdent.2017.02.007. Epub 2017 Feb 15. PMID: 28214537.

Madruga CFL, Bueno MG, Dal Piva AMO, Prochnow C, Pereira GKR, Bottino MA, et al. Sequential usage of diamond bur for CAD/CAM milling: Effect on the roughness, topography and fatigue strength of lithium disilicate glass ceramic. *J Mech Behav Biomed Mater.* 2019 Mar;91:326-34. doi: 10.1016/j.jmbbm.2018.12.037. Epub 2018 Dec 27. PMID: 30639981.

Magne P, Carvalho AO, Bruzi G, Anderson RE, Maia HP, Giannini M. Influence of no-ferrule and no-post buildup design on the fatigue resistance of endodontically treated molars restored with resin nanoceramic CAD/CAM crowns. *Oper Dent.* 2014 Nov-Dec;39(6):595-602. doi: 10.2341/13-004-L. Epub 2014 Aug 1. PMID: 25084102.

Magne P, Schlichting LH, Maia HP, Baratieri LN. In vitro fatigue resistance of CAD/CAM composite resin and ceramic posterior occlusal veneers. *J Prosthet Dent.* 2010 Sep;104(3):149-57. doi: 10.1016/S0022-3913(10)60111-4. PMID: 208132

Melo RM, Souza RO, Dursun E, Monteiro EB, Valandro LF, Bottino MA. Surface Treatments of Zirconia to Enhance Bonding Durability. *Oper Dent.* 2015 Nov-Dec;40(6):636-43. doi: 10.2341/14-144-L. Epub 2015 Jul 7. PMID: 26151461.

Mörmann WH, Bindl A, Lüthy H, Rathke A. Effects of preparation and luting system on all-ceramic computer-generated crowns. *Int J Prosthodont*. 1998 Jul-Aug;11(4):333-9. PMID: 9758997.

Monteiro JB, Oliani MG, Guilardi LF, Prochnow C, Rocha Pereira GK, Bottino MA, et al. Fatigue failure load of zirconia-reinforced lithium silicate glass ceramic cemented to a dentin analogue: Effect of etching time and hydrofluoric acid concentration. *J Mech Behav Biomed Mater*. 2018 Jan;77:375-82. doi: 10.1016/j.jmbbm.2017.09.028. Epub 2017 Sep 23. PMID: 28988143.

Munoz-Sanchez ML, Bessadet M, Lance C, Bonnet G, Veyrune JL, Nicolas E, et al. Survival Rate of CAD-CAM Endocrowns Performed by Undergraduate Students. *Oper Dent*. 2021 Sep 1;46(5):505-15. doi: 10.2341/20-126-C. PMID: 35486509.

Nishigawa K, Bando E, Nakano M. Quantitative study of bite force during sleep associated bruxism. *J Oral Rehabil*. 2001 May;28(5):485-91. doi: 10.1046/j.1365-2842.2001.00692.x. PMID: 11380790.

Pang Z, Chughtai A, Sailer I, Zhang Y. A fractographic study of clinically retrieved zirconia-ceramic and metal-ceramic fixed dental prostheses. *Dent Mater*. 2015 Oct;31(10):1198-206. doi: 10.1016/j.dental.2015.07.003. Epub 2015 Jul 29. PMID: 26233469; PMCID: PMC4575279.

Pereira GKR, Graunke P, Maroli A, Zucuni CP, Prochnow C, Valandro LF, et al. Lithium disilicate glass-ceramic vs translucent zirconia polycrystals bonded to distinct substrates: Fatigue failure load, number of cycles for failure, survival rates, and stress distribution. *J Mech Behav Biomed Mater*. 2019 Mar;91:122-30. doi: 10.1016/j.jmbbm.2018.12.010. Epub 2018 Dec 12. PMID: 30579109

Pereira GKR, Guilardi LF, Dapieve KS, Kleverlaan CJ, Rippe MP, Valandro LF. Mechanical reliability, fatigue strength and survival analysis of new polycrystalline translucent zirconia ceramics for monolithic restorations. *J Mech Behav Biomed Mater*. 2018 Sep;85:57-65. doi: 10.1016/j.jmbbm.2018.05.029. Epub 2018 May 23. PMID: 29857261.

Piconi C, Maccauro G. Zirconia as a ceramic biomaterial. *Biomaterials*. 1999 Jan;20(1):1-25. doi: 10.1016/s0142-9612(98)00010-6. PMID: 9916767.

Pissis P. Fabrication of a metal-free ceramic restoration utilizing the monobloc technique. *Pract Periodontics Aesthet Dent*. 1995 Jun-Jul;7(5):83-94. PMID: 7548896.

Ramakrishnaiah R, Alkheraif AA, Divakar DD, Matinlinna JP, Vallittu PK. The Effect of Hydrofluoric Acid Etching Duration on the Surface Micromorphology, Roughness, and Wettability of Dental Ceramics. *Int J Mol Sci*. 2016 May 27;17(6):822. doi: 10.3390/ijms17060822. PMID: 27240353; PMCID: PMC4926356.

Ramírez-Sebastià 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):545-54. doi: 10.1007/s00784-013-0978-3. Epub 2013 Apr 20. PMID: 23604697.

Reeh ES, Messer HH, Douglas WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. *J Endod*. 1989 Nov;15(11):512-6. doi: 10.1016/S0099-2399(89)80191-8. PMID: 2639947.

Rocca GT, Daher R, Saratti CM, Sedlacek R, Suchy T, Feilzer AJ, et al. Restoration of severely damaged endodontically treated premolars: The influence of the endo-core length on marginal integrity and fatigue resistance of lithium disilicate CAD-CAM ceramic endocrowns. *J Dent*. 2018 Jan;68:41-50. doi: 10.1016/j.jdent.2017.10.011. Epub 2017 Oct 26. Erratum in: *J Dent*. 2018 Sep;76:139. PMID: 29107134.

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 Jun;31(6):603-23. doi: 10.1016/j.dental.2015.02.011. Epub 2015 Apr 2. Erratum in: *Dent Mater*. 2016 Dec;32(12):e389-e390. PMID: 25842099.

Salis SG, Hood JA, Stokes AN, Kirk EE. Patterns of indirect fracture in intact and restored human premolar teeth. *Endod Dent Traumatol*. 1987 Feb;3(1):10-4. doi: 10.1111/j.1600-9657.1987.tb00165.x. PMID: 3471511.

Samran A, El Bahra S, Kern M. The influence of substance loss and ferrule height on the fracture resistance of endodontically treated premolars. *An in vitro*

study. *Dent Mater*. 2013 Dec;29(12):1280-6. doi: 10.1016/j.dental.2013.10.003. Epub 2013 Oct 30. PMID: 24182949

Sax C, Hämmerle CH, Sailer I. 10-year clinical outcomes of fixed dental prostheses with zirconia frameworks. *Int J Comput Dent*. 2011;14(3):183-202. English, German. PMID: 22141229.

Schwartz RS, Robbins JW. Post placement and restoration of endodontically treated teeth: a literature review. *J Endod*. 2004 May;30(5):289-301. doi: 10.1097/00004770-200405000-00001. PMID: 15107639.

Sedgley CM, Messer HH. Are endodontically treated teeth more brittle? *J Endod*. 1992 Jul;18(7):332-5. doi: 10.1016/S0099-2399(06)80483-8. PMID: 1402595.

Soderholm KJ. Review of the fracture toughness approach. *Dent Mater*. 2010 Feb;26(2):e63-77. doi: 10.1016/j.dental.2009.11.151. Epub 2009 Dec 31. PMID: 20045178.

Souza AC, Xavier TA, Platt JA, Borges AL. Effect of Base and Inlay Restorative Material on the Stress Distribution and Fracture Resistance of Weakened Premolars. *Oper Dent*. 2015 Jul-Aug;40(4):E158-66. doi: 10.2341/14-229-L. Epub 2015 Mar 12. PMID: 25764042.

Souza R, Barbosa F, Araújo G, Miyashita E, Bottino MA, Melo R, et al. Ultrathin Monolithic Zirconia Veneers: Reality or Future? Report of a Clinical Case and One-year Follow-up. *Oper Dent*. 2018 Jan/Feb;43(1):3-11. doi: 10.2341/16-350-T. PMID: 29284106; PMCID: PMC5808436.

Taha D, Spintzyk S, Schille C, Sabet A, Wahsh M, Salah T, et al. Fracture resistance and failure modes of polymer infiltrated ceramic endocrown restorations with variations in margin design and occlusal thickness. *J Prosthodont Res*. 2018 Jul;62(3):293-7. doi: 10.1016/j.jpor.2017.11.003. Epub 2017 Dec 11. PMID: 29241944.

Teja SS, Teja PH. All-ceramic materials in dentistry. *Saint's Int Dent J*. 2015 Jul 1;1(2):91-5. doi: 10.4103/2454-3160.177930.

Tribst JP, Dal Piva AO, Madruga CF, Valera MC, Bresciani E, Bottino MA, et al. The impact of restorative material and ceramic thickness on CAD\CAM endocrowns. *J Clin Exp Dent*. 2019 Nov 1;11(11):e969-e977. doi: 10.4317/jced.56002. PMID: 31700569; PMCID: PMC6825739.

Tribst JPM, Dal Piva AMO, Madruga CFL, Valera MC, Borges ALS, Bresciani E, et al. Endocrown restorations: Influence of dental remnant and restorative material on stress distribution. *Dent Mater*. 2018 Oct;34(10):1466-1473. doi: 10.1016/j.dental.2018.06.012. Epub 2018 Jun 21. PMID: 29935769.

Vagkopoulou T, Koutayas SO, Koidis P, Strub JR. Zirconia in dentistry: Part 1. Discovering the nature of an upcoming bioceramic. *Eur J Esthet Dent*. 2009 Summer;4(2):130-51. PMID: 19655651.

Velho HC, Dapieve KS, Borges ALS, Pereira GKR, Venturini AB, Valandro LF. Effects of material and piston diameter on the fatigue behavior, failure mode, and stress distribution of feldspathic ceramic simplified restorations. *J Mech Behav Biomed Mater*. 2022 Oct;134:105398. doi: 10.1016/j.jmbbm.2022.105398. Epub 2022 Aug 1. PMID: 35961241.

Warreth A, Elkareimi Y. All-ceramic restorations: A review of the literature. *Saudi Dent J*. 2020 Dec;32(8):365-72. doi: 10.1016/j.sdentj.2020.05.004. Epub 2020 May 29. PMID: 34588757; PMCID: PMC8461086.

Widmalm SE, Ericsson SG. Maximal bite force with centric and eccentric load. *J Oral Rehabil*. 1982 Sep;9(5):445-50. doi: 10.1111/j.1365-2842.1982.tb01034.x. PMID: 6957576.

Willard A, Gabriel Chu TM. The science and application of IPS e.Max dental ceramic. *Kaohsiung J Med Sci*. 2018 Apr;34(4):238-42. doi: 10.1016/j.kjms.2018.01.012. Epub 2018 Feb 9. PMID: 29655413.

Zarone F, Di Mauro MI, Ausiello P, Ruggiero G, Sorrentino R. Current status on lithium disilicate and zirconia: a narrative review. *BMC Oral Health*. 2019 Jul 4;19(1):134. doi: 10.1186/s12903-019-0838-x. PMID: 31272441; PMCID: PMC6610968.

Zhang F, Reveron H, Spies BC, Van Meerbeek B, Chevalier J. Trade-off between fracture resistance and translucency of zirconia and lithium-disilicate

glass ceramics for monolithic restorations. *Acta Biomater.* 2019 Jun;91:24-34. doi: 10.1016/j.actbio.2019.04.043. Epub 2019 Apr 26. PMID: 31034947.

Zhang Y, Lawn BR. Novel Zirconia Materials in Dentistry. *J Dent Res.* 2018 Feb;97(2):140-7. doi: 10.1177/0022034517737483. Epub 2017 Oct 16. PMID: 29035694; PMCID: PMC5784474.

Zhang Y, Sailer I, Lawn BR. Fatigue of dental ceramics. *J Dent.* 2013 Dec;41(12):1135-47. doi: 10.1016/j.jdent.2013.10.007. Epub 2013 Oct 14. PMID: 24135295; PMCID: PMC3877306.

Zhang Y, Vardhaman S, Rodrigues CS, Lawn BR. A Critical Review of Dental Lithia-Based Glass-Ceramics. *J Dent Res.* 2023 Mar;102(3):245-53. doi: 10.1177/00220345221142755. Epub 2023 Jan 16. PMID: 36645131; PMCID: PMC9947811.

Zhang Y. Making yttria-stabilized tetragonal zirconia translucent. *Dent Mater.* 2014 Oct;30(10):1195-203. doi: 10.1016/j.dental.2014.08.375. Epub 2014 Sep 2. PMID: 25193781; PMCID: PMC4167579.

Zhu J, Rong Q, Wang X, Gao X. Influence of remaining tooth structure and restorative material type on stress distribution in endodontically treated maxillary premolars: A finite element analysis. *J Prosthet Dent.* 2017 May;117(5):646-55. doi: 10.1016/j.prosdent.2016.08.023. Epub 2016 Oct 27. PMID: 27881319.