Thickness Effect of Monolithic-Supported Implant Restoration for Bruxism Patients

[1]Elaf Jamal Harb, BSc and [2]Sabiha Mahdi Kanaan, MSc.
[1,2] Department of Prosthesis Dental Technology, College of Health and Medical Technology, Middle Technical University, Iraq.
Corresponding author: Elaf Jamal Harb
E-mail: elaphharbjamal@gmail.com

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Abstract

Background Patients with bruxism require a complex approach to treatment to resist the force of bruxism; the treatments must be made of strong materials. **Objectives** of the present study was a numerical investigation of the restoration's stress distribution and total deformation according to the restorative materials utilized in posterior monolithic restoration supported by the implant in patients with bruxism using finite element analysis (FEA). **Materials and Methods** The model of all-ceramic restoration for implant posterior molar constructed with CAD/CAM technology was transferred into a three-dimensional FEA program. Six finite element models with occlusal thicknesses of 0.5, 0.7, and 1.0mm in lithium disilicate glass-ceramic and zirconia were simulated utilizing two various loads (to act bruxism type) clenching type (vertical 812 N) while clenching + grinding type (vertical 812 N) plus torque load of (10, 50, and 100 N). **Results** The highest stress values and lowest total deformation were fixed on prostheses with a thickness of 1.0mm in various loading directions and various materials. The restorations made of zirconia with a thickness of 1.0 mm exhibited the highest stress values and lowest total deformation. **Conclusions** The stress distribution and total deformation of ceramic restorations are dependent on the restoration's thickness.

Keywords: 3D FEA; stress; all-ceramic crown; thickness; implant; bruxism.

Introduction

Numerous prosthetic procedures are available to restore lost teeth. Implant-supported fixed dental prostheses are one of these procedures for replacing lost or multiple posterior teeth (FDP), (Iranmanesh et al, 2014). The ability to resist masticatory force and the esthetic outcome are also factors that play an important role in selecting a prosthetic restorative material, (Raigrodski et al, 2012). Generally, noble metallic crowns have been used as the gold standard. Metallic crowns have decreased in popularity due to the cosmetic enhancement of other restorative materials and the option of using dental ceramics in metals for the same reason. Monolithic ceramic materials have been created to overcome the difficulties of concealing ceramic failures in metal-ceramic and all-ceramic crowns, (Dal Piva et al, 2018b). As a result, many researchers that analyzed the fracture strength of all-ceramic monolithic crowns found that the monolithic structure exceeded the veneered one,(Beuer et al, 2008; Beuer et al, 2012; SILVA et al, 2017). Zirconia and lithium disilicate is the most common monolithic material, (Biscaro et al., 2013). Lithium disilicate seems to have a stronger translucency than zirconia but a lower mechanical strength, (Chu, 2012). The flexural strength of high translucency zirconia is twice as high as that of lithium disilicate, (Tribst et al, 2018). The mechanical characteristics of restorative materials included fatigue failure, the magnitude of occlusal forces, and crown thickness, which influence their long-term performance and survival rate, (Lameira et al, 2015). Many researchers compared lithium disilicate and zirconia and discovered that LD fractures faster than zirconia under similar circumstances because lithium disilicate has a lower tensile strength value than zirconia (Dejak et al, 2012; Amin et al, 2017). The masticatory system›s activities can be classified into two categories: functional activities such as chewing and speaking, and parafunctional activities such as teeth clenching or grinding (referred to as bruxism), (Reddy et al, 2014). Bruxism is a parafunctional masticatory system characterized by unconscious teeth clenching and grinding in the absence of neuromuscular protective mechanisms, (Demjaha et al, 2019). Sleep bruxism (abbreviated as SB) is described as a rhythmic (phasic) or non-rhythmic (tonic) masticatory-muscle action during sleep that is not associated with movement or sleep disorders in otherwise healthy persons. Awake bruxism (abbreviated as AB) is defined as masticatory-muscle activity that occurs during wakefulness and is characterized by repeated or persistent tooth contact and/or bracing or thrusting of the mandible. It is not a movement condition in otherwise healthy individuals, (Levartovsky et al, 2019). According to the American Academy of Orofacial Pain (AAOP), bruxism is a parafunctional activity that involves both grinding and clenching. Clenching unlike grinding, the centric bruxism is clenching, while an eccentric bruxism is grinding. Clenching is a static process of closing the mandible and maxilla with force, causing the opposing teeth to contact an eccentric angle. On the other hand, grinding is a dynamic process in which the mandibular arch moves in different directions, causing dentation to slide over each other, (Alharby et al, 2018). Because of the way "bruxers" distribute their muscular power to their teeth and surrounding tissues, they may experience tooth wear, orofacial pain, and hyperactive and enlarged masticatory muscles, especially the masseter. Since muscles are the primary source of bite force, increases in muscular function may be expressed numerically by increases in the maximum biting force (MBF). According to previous studies by Lassila et al, (1985), and Castelo et al, (2008), MBF is associated with different factors including gender, craniofacial morphology (including periodontal sensitivity), dental occlusal status (including the occlusal level of the teeth), and the presence or absence of symptoms associated with temporomandibular disorders, (Castelo et al., 2008, Lassila et al., 1985). MBF values ranged from 388N to 1,109 N in the cases investigated, (Todic et al, 2016). A dental implant is an alloplastic device surgically inserted into the oral tissues under the mucosa and periosteal layer, either on top of or inside the bone, to provide retention and stability for a fixed or removable dental prosthesis, (Bhandari et al, 2020). Biological and mechanical considerations influence the longevity and performance of an implant-supported prosthesis. There have been two main types of implant failures, early and late losses. A lack of osseointegration identifies early failures, mainly occur following surgery. On the other hand, late shortcomings relate to implants that have been assumed to be effective for a long time but have failed following prosthetic restoration. Mechanical complications are the most usual of which are metal fatigue induced by biomechanical overloading, which causes abutment or prosthetic screw loosening or fracture and wears and fracture of the prosthesis or other device components, (Lan et al., 2019), So prior to implant restoration, the occlusal plane or anterior incisal guidance may need to be modified to eliminate all posterior contacts during mandibular excursions, (Resnik and Misch, 2018). While, biological complications result in the loss of supporting tissue, such as infection or peri-implantitis, (Lan et al, 2019). Bruxism has also been associated with greater (occlusal) loading on dental implants and superstructures, producing bone damage or even failure. As a result, bruxism is usually seen as a factor for fear, if not an outright contraindication, when implant placement, (Lobbezoo et al, 2006). According to Sheridan et al, (2016), the implementation of clinical suggestions such as optimizing force direction along the long axis of the implant, decreasing force magnification by increasing the prosthesis contact area, and expanding the implant prosthesis support area would be beneficial in clinical applications, (Sheridan et al, 2016). The force exerted by clenching or grinding actions on an implant prosthesis must be managed by the device when it's used to treat bruxism. A dentist can collaborate with a patient's surgeon to determine the cause and develop a plan for fabricating dental prostheses that are high-load bearing, or stress-relieving, in nature. Patients suffering from bruxism problems have often benefited completely from a metal prosthesis, which has been widely used by practitioners, (Mehta et al, 2012a, Mehta et al, 2012b). The use of numerical models to simulate the mechanical behavior of any structures has been recognized as an effective technique due to their low-cost and to overcome the difficulties of in vitro and in vivo studies. Finite element analysis (FEA) is a method of evaluating stress and strain patterns in a three-dimensional (3D) model used to create a computer simulation. FEA has previously been used in many studies to evaluate the deformation of an individual component of many restored teeth, (Maghami et al, 2018). The application of FEA took place to investigate the impact of various materials on monolithic complete posterior crowns. Numerous variables can have an effect on the resulting stress distribution, such as the magnitude and direction of applied forces, (Motta et al, 2008). They discovered that materials with a high elastic modulus allow for greater tensile stress concentration on the crown intaglio surface, (Dal Piva et al, 2018a). Numerical simulation was used to evaluate the effect of different framework materials on stress distribution in a posterior three-unit fixed dental prosthesis. It was concluded that special attention should be paid to the finish line contact with the fixed dental prosthesis to avoid stress concentration, (Attia, 2018). The purpose of this study is to apply finite element analysis to evaluate the stress distribution and total deformation of posterior monolithic single crown restoration supported by implants in patients with bruxism, and depending on the restorative materials employed. The present study hypotheses were that firstly, there would be differences in stress distribution and total deformation in the restoration based on the occlusal thickness; and secondly, there would be variations in stress distribution and total deformation in the restoration depending on the type of bruxism.

Material and Methods

1. The 3D designing of models

Abutment with an implant was prepared and scanned using the ARTI S600 dental scanner (ZirkonZahn, Italy). The data was uploaded as a stereolithography (STL) file to ZirkonZahn software (ZirkonZahn, Italy) to create the restoration with different thicknesses of (0.5, 0.7, and 1mm), then the 3D solid model for FEA was generated using the geomagic software application (geomagic 2014).

2. Finite element analysis (FEA)

The finite element was performed using the ANSYS 2020 R2 software (ANSYS, Canonsburg, PA, USA). The procedure included three phases, the pre-processing, processing, and post-processing phases. As part of the pre-processing phase, the mechanical characteristics of the 3D model components were used for the restoration as determined in Table (1). Zirconia and lithium disilicate was used to fabricate the restoration. All materials were homogeneous, isotropic, and linearly elastic. Each model was split into tiny components called "elements" which linked through points called "nodes" to form a mesh structure throughout the procedure. The parabolic tetrahedral solid components are utilized to create a fine solid mesh. Table (2) summarizes the total number of study elements and nodes. During the processing stage, a circular indenter (4mm in diameter) was produced as a portion of the 3D model used to apply load to the restoration center during the testing phase. The implant is fixed so that the force is applied just in the direction of restoration.

There are four various loading conditions applied for each material to simulated bruxism.

A. Vertical loading of 812 N (representing clenching)

B. Vertical loading of 812 N+ torque loading 10N (representing clenching+ grinding)

C. Vertical loading of 812 N+ torque loading 50N (representing clenching+ grinding)

D. Vertical loading of 812 N+torque loading 100N (representing clenching +grinding)

The load is stepped at (100000 cycles)

During the post-processing phase, the results of the processing phase were shown in the form of graphical and numerical outputs in the form of maximum principal stress (tensile stress values) and total deformation. Analysis simulation software (ANSYS) displays the findings using a chromatic scale of colors ranging from blue lowest values to red highest values.

Results

A qualitative evaluation for the maximum tensile stress and total deformation of the restoration's occlusal surface was performed after establishing the mesh for the 3D model in FEA, Figure (1). FEA was used to evaluate the fracture resistance of all-ceramic CAD/CAM crown restoration with different thicknesses. The vertical force is applied to simulate the clenching condition, and a vertical force with a moment force is applied to represent the grinding+clinching condition. The findings demonstrate that zirconia exhibits tremendous stress distribution with the slowest deformation rate in both situations. Zirconia restoration with 1mm thickness shows the highest stress distribution with the lowest deformation. Additionally, when the thickness was 0.5mm, the maximum tensile stress and total deformation from V812 N+T100N were more significant than those of only V 812N.

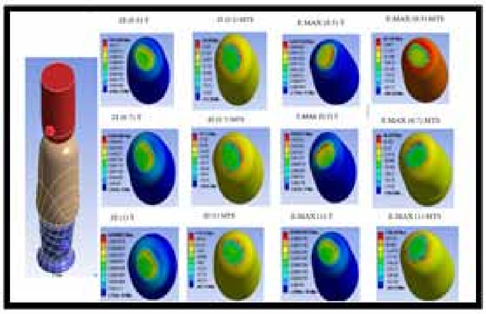

Figure (1): Total deformation (T) and distribution of maximum tensile stress (MTS) in E.MAX CAD and zirconia (zi) at various thickness of (0.5, 0.7and 1mm) when applied vertical force (A) to acts the clenching type.

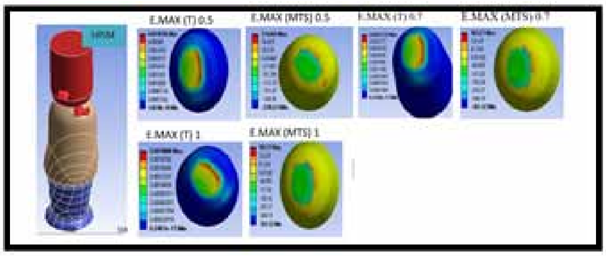

Figure (2): Total deformation (T) and distribution of maximum tensile stress (MTS) of E.MAX CAD after applied vertical load (A) of 812N and torque load (B) 10N under various thickness of (0.5, 0.7, and 1mm).

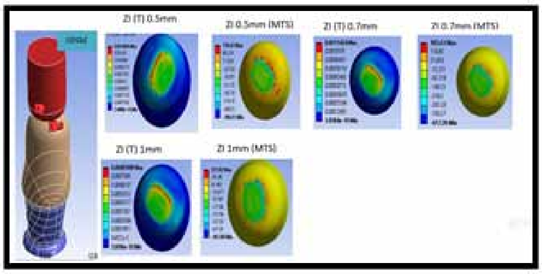

Figure (3): Total deformation (T) and distribution of maximum tensile stress (MTS)of ZIRCONIA after applied vertical load (A) of 812N and torque load (B) 10N under various thickness of (0.5, 0.7, and 1mm).

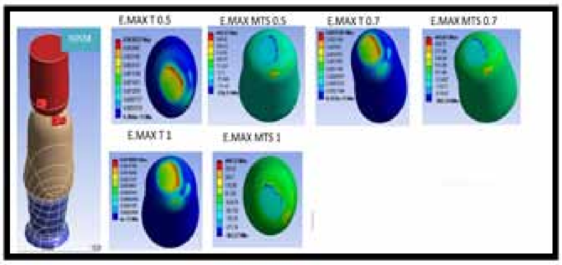

Figure (4): Total deformation (T) and distribution of maximum tensile stress (MTS) of E.MAX CAD after applied vertical load(A) of 812N and torque load (B) 50N under various thickness of (0.5, 0.7, and 1mm).

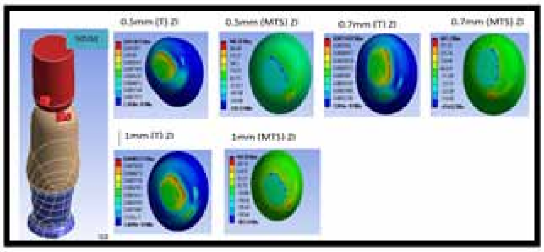

Figure (5): Total deformation (T) and distribution of maximum tensile stress (MTS) of ZIRCONIA after applied vertical load (A) of 812N and torque load (B) 50N under various thickness of (0.5, 0.7, and 1mm).

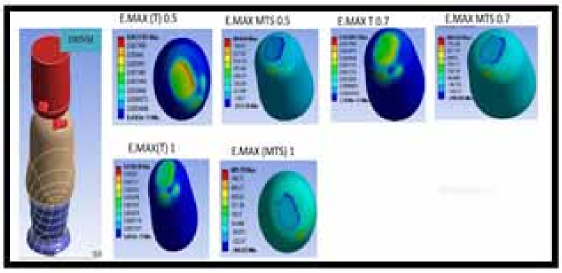

Figure (6) :Total deformation (T) and distribution of maximum tensile stress (MTS)of E.MAX CAD after applied vertical load (A) of 812N and torque load(B) 100N under various thickness of (0.5, 0.7, and 1mm).

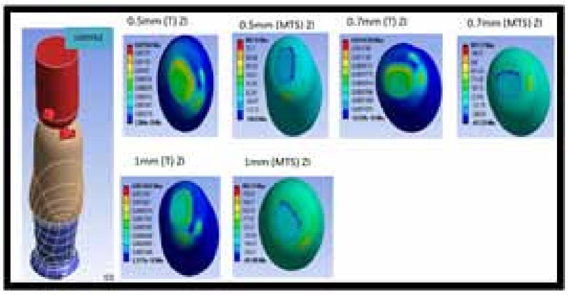

Figure (7): Total deformation (T) and distribution of maximum tensile stress (MTS) of ZIRCONIA after applied vertical load (A) of 812N and torque load (B) 100N under various thickness of (0.5, 0.7, and 1mm).

Table (1): Study materials' mechanical properties.

Materials	Materials' mechanical properties, units and references			
	Elastic modulus (Gpa)	Poisson's ratio	Tensile strength (MPa)	References
E.MAX CAD	95	0.25	43.4	(Amin et al., 2017)
ZIRCONIA	210	0.30	745	(Dejak et al., 2012)
TITANIUM	110	0.33	795	(Nicholson, 2020, Lan et al., 2019)

Table (2): Element and nodes are calculated for the model.

Structure	No. of elements	No. of nodes
Restoration on abutment	74805	111700

Discussion

The present study aimed to evaluate the impact of bruxism forces applied on two types of restorative monolithic materials at three different thicknesses using FEA. Regarding the results, the first and second study hypotheses were accepted as the thickness of the restorative material impacted the restoration mechanically, and the type of bruxism affected restoration longevity. This study aimed to apply a vertical load to represent clenching as in Figure (1) (night or nocturnal bruxism), (Reddy et al, 2014). The maximum tensile stress increased and the total deformation decreased as the restoration thickness increased. The highest stress and lowest total deformation results were obtained in all the restorations of 1.0mm thickness. Compared to the other thickness, the restorations of 0.5mm thickness displayed a lower level of stress and higher deformation. According to researchers, bruxism (tooth grinding) causes an overload of teeth, implants, and restorations. Since individuals with bruxism might damage the surface used to treat their condition, researchers advise using an occluding surface that will not chip, such as metal or a monolithic ceramic substance, (Levartovsky et al, 2019). It simulated clenching and grinding when the loading included vertical force and torque load, Figures (2 to 7) (day or diurnal bruxism), (Reddy et al, 2014). When the thickness exceeded 0.5mm, the stress value seems to be higher with lower deformation. Therefore, the V812N+T100N was more significant than those caused by vertical force alone. Due to the increased stress and decreased total deformation, the 1.0mm thickness of zirconia material is advantageous for posterior implant prostheses in patients who suffer from bruxism. Dejak et al, (2012) and Amin et al, (2017) observed the E.MAX CAD ceramic with a lower tensile strength value than zirconia, the findings obtained from samples under identical conditions showed that E.MAX CAD would fail quicker than zirconia, (Dejak et al, 2012; Amin et al, 2017). Tribst et al, clarified zirconia with the most significant elastic modulus, resulting in more tensile stress localized on the intaglio surface, (Tribst et al, 2018). Nevertheless, it is impossible to state whether or not this material will fracture earlier than simulated glassy ceramics because of its hardness. In 2008, Motta et al. showed that stress distribution varies depending on load direction (Motta et al, 2008). Furthermore, Iranmanesh et al, 2014 claim that many variables, such as the direction and intensity of the applied load can alter stress distribution resulting in fracture and failure, (Iranmanesh et al, 2014). Grinding and clenching are two of the most frequent parafunction behaviors associated with bruxism. The act of clenching always includes a significant amount of occlusal force. In addition to making a loud noise while sleeping, grinding may cause tooth surface loss in either a horizontal or an oblique direction, depending on the intensity of the grinding activity, (Lan et al, 2019). This may lead to tooth wear in the form of vertical, horizontal or mixed tooth surface loss. When tooth wear is seen in the posterior regions, it is classified as severe bruxism. Extensive attrition tooth erosion in patients with severe bruxism frequently demands the cosmetic and functional rehabilitation of full dentition. Such intensive treatments present a significant challenge to the dentist, dental technician, and patient. In those cases, increasing the vertical dimension of occlusion (VDO) is advantageous because it provides room for restorative material and increases the level of tooth displayed while minimizing necessity biologically invasive clinical procedures such as crown lengthening or elective endodontic treatment, (Levartovsky et al, 2019). Clinical experience shows that posterior wear patterns are significantly more difficult to manage because they usually stem from an absence of anterior guidance during excursions, and the posterior teeth when making contact during excursive jaw positions, are subject to larger forces, so before an implant restoration, changes to the anterior incisal guidance or the occlusal plane may be necessary to ensure all posterior contacts are eliminated during mandibular excursions (Resnik and Misch, 2018).

Conclusions

According to the present study limitation and analyzes, E.MAX CAD is more susceptible to failure than zirconia. With increasing the thickness, the stress value of the restoration increased and the total deformation decreased. According to the results, the 1.0mm thickness had the highest stress distribution and the lowest total deformation with different loading directions. So, it shows an advantage to be applicable in a posterior zirconia-supported implant with 1mm thickness for patients having bruxism.

Conflict of interest

We are the authors (Elaf Jamal Harb, Assist. Prof. Sabiha Mahdi Kanaan) state that the submitted manuscript for this paper is original. It has not been published previously, and it's part of the MSc. dissertation and is not under consideration for publication elsewhere, and that the final version has been seen and approved by all authors.

References

ALHARBY, A., ALZAYER, H., ALMAHLAWI, A., ALRASHIDI, Y., AZHAR, S., SHEIKHO, M., ALANDIJANI, A., ALJOHANI, A. & OBIED, M. 2018. Parafunctional behaviors and its effect on dental bridges. Journal of clinical medicine research, 10, 73. https://doi: 10.14740/jocmr3304w.

AMIN, R. A., ABDELLATIF, M. A. & ELTAYEB, H. E. 2017. FRACTURE RESISTANCE, FINITE ELEMENT ANALYSIS AND WEIBULL RISK OF FAILURE FOR ENDODONTICALLY TREATED MOLARS RESTORED WITH LITHIUM DISILICATE AND HYBRID CERAMIC ENDOCROWNS WITH TWO PREPARATION DESIGNS. Egyptian Dental Journal, 63, 2803-2820. https://doi: 10.21608/EDJ.2017.76330

ATTIA, M. A. 2018. EFFECT OF MATERIAL TYPE ON THE STRESS DISTRIBUTION IN POSTERIOR THREE-UNIT FIXED DENTAL PROSTHESIS: A THREE-DIMENSIONAL FINITE ELEMENT ANALYSIS. Egyptian Dental Journal, 64, 3907-3918. https://doi: 10.21608/edj.2018.79505

BEUER, F., SCHWEIGER, J. & EDELHOFF, D. 2008. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. British dental journal, 204, 505-511. https://doi: 10.1038/sj.bdj.2008.350.

BEUER, F., STIMMELMAYR, M., GUETH, J.-F., EDELHOFF, D. & NAUMANN, M. 2012. In vitro performance of full-contour zirconia single crowns. Dental materials, 28, 449-456.https://doi: 10.1016/j.dental.2011.11.024.

BHANDARI, J., ADHAPURE, P., BARVE, N. N., BAIG, N., JADHAV, V. & VISPUTE, S. 2020. Full mouth rehabilitation by implant supported fixed prosthesis. Contemporary Clinical Dentistry, 11, 199. https://doi: 10.4103/ccd.ccd_738_18.

BISCARO, L., BONFIGLIOLI, R., SOATTIN, M. & VIGOLO, P. 2013. An in vivo evaluation of fit of zirconium-oxide based ceramic single crowns, generated with two CAD/CAM systems, in comparison to metal ceramic single crowns. J Prosthodont, 22, 36-41. https://doi: 10.1111/j.1532-849X.2012.00907.x

CASTELO, P. M., BONJARDIM, L. R., PEREIRA, L. J. & GAVIÃO, M. B. 2008. Facial dimensions, bite force and masticatory muscle thickness in preschool children with functional posterior crossbite. Braz Oral Res, 22, 48-54. https://doi: 10.1111/j.1532-849X.2012.00907.x

CHU, S. J. 2012. Current clinical strategies with lithium-disilicate restorations. Compend Contin Educ Dent, 33, 64, 66-7.

DAL PIVA, A. M. D. O., TRIBST, J. P. M., BORGES, A. L. S., E SOUZA, R. O. D. A. & BOTTINO, M. A. 2018a. CAD-FEA modeling and analysis of different full crown monolithic restorations. Dental Materials, 34, 1342-1350. https://doi: 10.1016/j.dental.2018.06.024

DAL PIVA, A. M. O., TRIBST, J. P. M., BORGES, A. L. S., SOUZA, R. & BOTTINO, M. A. 2018b. CAD-FEA modeling and analysis of different full crown monolithic restorations. Dent Mater, 34, 1342-1350. https://doi.org/10.1016/j.dental.2018.06.024

DEJAK, B., MŁOTKOWSKI, A. & LANGOT, C. 2012. Three-dimensional finite element analysis of molars with thin-walled prosthetic crowns made of various materials. Dental Materials, 28, 433-441. https://doi: 10.1016/j.dental.2011.11.019

DEMJAHA, G., KAPUSEVSKA, B. & PEJKOVSKA-SHAHPASKA, B. 2019. Bruxism Unconscious Oral Habit in Everyday Life. Open Access Maced J Med Sci, 7, 876-881. https://doi: 10.3889/oamjms.2019.196

IRANMANESH, P., ABEDIAN, A., NASRI, N., GHASEMI, E. & KHAZAEI, S. 2014. Stress analysis of different prosthesis materials in implant-supported fixed dental prothesis using 3D finite element method. Dental Hypotheses, 5, 109-114.

LAMEIRA, D. P., BUARQUE E SILVA, W. A., ANDRADE E SILVA, F. & DE SOUZA, G. M. 2015. Fracture Strength of Aged Monolithic and Bilayer Zirconia-Based Crowns. Biomed Res Int, 2015, 418641. https://doi: 10.1155/2015/418641

LAN, T.-H., PAN, C.-Y., LIU, P.-H. & CHOU, M. 2019. Fracture resistance of monolithic zirconia crowns in implant prostheses in patients with bruxism. Materials, 12, 1623. https://doi: 10.3390/ma12101623

LASSILA, V., HOLMLUND, I. & KOIVUMAA, K. K. 1985. Bite force and its correlations in different denture types. Acta Odontol Scand, 43, 127-32. https://doi: 10.3109/00016358509064142

LEVARTOVSKY, S., PILO, R., SHADUR, A., MATALON, S. & WINOCUR, E. 2019. Complete rehabilitation of patients with bruxism by veneered and non-veneered zirconia restorations with an increased vertical dimension of occlusion: an observational case-series study. J Prosthodont Res, 63, 440-446.https://doi: 10.1016/j.jpor.2019.02.006

LOBBEZOO, F., BROUWERS, J., CUNE, M. & NAEIJE, M. 2006. Dental implants in patients with bruxing habits. Journal of oral rehabilitation, 33, 152-159. https://doi: 10.1111/j.1365-2842.2006.01542.x

MAGHAMI, E., HOMAEI, E., FARHANG-DOOST, K., POW, E. H. N., MATINLINNA, J. P. & TSOI, J. K.-H. 2018. Effect of preparation design for all-ceramic restoration on maxillary premolar: a 3D finite element study. Journal of prosthodontic research, 62, 436-442. https://doi.org/10.1016/j.jpor.2018.04.002

MEHTA, S. B., BANERJI, S., MILLAR, B. J. & SUAREZ-FEITO, J. M. 2012a. Current concepts on the management of tooth wear: part 1. Assessment, treatment planning and strategies for the prevention and the passive management of tooth wear. Br Dent J, 212, 17-27. https://doi: 10.1038/sj.bdj.2011.1099

MEHTA, S. B., BANERJI, S., MILLAR, B. J. & SUAREZ-FEITO, J. M. 2012b. Current concepts on the management of tooth wear: part 4. An overview of the restorative techniques and dental materials commonly applied for the management of tooth wear. Br Dent J, 212, 169-77. https://doi: 10.1038/sj.bdj.2012.137

MOTTA, A. B., PEREIRA, L. C., DA CUNHA, A. R. & DUDA, F. P. 2008. The influence of the loading mode on the stress distribution on the connector region of metal-ceramic and all-ceramic fixed partial denture. Artificial organs, 32, 283-291. https://doi: 10.1111/j.1525-1594.2008.00544.x

RAIGRODSKI, A. J., HILLSTEAD, M. B., MENG, G. K. & CHUNG, K. H. 2012. Survival and complications of zirconia-based fixed dental prostheses: a systematic review. J Prosthet Dent, 107, 170-7. https://doi: 10.1016/S0022-3913(12)60051-1

REDDY, S. V., KUMAR, M. P., SRAVANTHI, D., MOHSIN, A. H. B. & ANUHYA, V. 2014. Bruxism: a literature review. Journal of international oral health: JIOH, 6, 105.

RESNIK, R. R. & MISCH, C. E. 2018. 3 - Treatment Planning Complications. In: RESNIK, R. R. & MISCH, C. E. (eds.) Misch›s Avoiding Complications in Oral Implantology. Mosby. https://doi.org/10.1016/B978-0-323-37580-1.00003-2

SHERIDAN, R. A., DECKER, A. M., PLONKA, A. B. & WANG, H. L. 2016. The Role of Occlusion in Implant Therapy: A Comprehensive Updated Review. Implant Dent, 25, 829-838. https://doi: 10.1097/ID.0000000000000488

SILVA, L. H. D., LIMA, E. D., MIRANDA, R. B. D. P., FAVERO, S. S., LOHBAUER, U. & CESAR, P. F. 2017. Dental ceramics: a review of new materials and processing methods. Brazilian oral research, 31. https://doi: 10.1590/1807-3107BOR-2017.vol31.0058

TODIC, J., MITIC, A., LAZIC, D., RADOSAVLJEVIC, R. & STALETOVIC, M. 2016. Effects of bruxism on the maximum bite force. Vojnosanitetski pregled, 74, 165-165. https://doi.org/10.2298/VSP150327165T.

TRIBST, J., DAL PIVA, A., PENTEADO, M., BORGES, A. & BOTTINO, M. 2018. Influence of ceramic material, thickness of restoration and cement layer on stress distribution of occlusal veneers. Brazilian Oral Research, 32. https://doi: 10.1590/1807-3107bor-2018.vol32.0118.