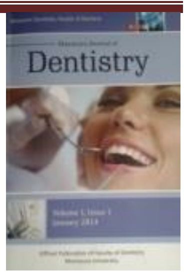

Influence of Speed Sintering Protocol on Marginal Adaptation of High Translucent Zirconia Fixed Restorations

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Abstract:

Statement of problem:Is the speed sintering protocol harmfully affecting the marginal adaptation of high translucent zirconia crowns, or it is save to use in addition to saving time and electrical power comparing with conventional sintering protocols!

Objective: Studying the effect of speed sintering protocol on marginal adaptation of two types of high translucent zirconia crown restorations.

Materials and methods:Twenty extracted human maxillary premolars were randomly divided into two main groups according to type of zirconia material used, each tooth was received two similar crowns, one conventionally sintered, the other was speed sintered. The two main groups (n=20): group (K); teeth were restored with KATANA STML crowns, and group (Z); teeth were restored with Zolid fx white crowns.Each group were further subdivided into two subgroups according to sintering protocols (n=10): (KC); conventionally sintered KATANA STML crowns, (KS); speed sintered KATANA STML crowns, (ZC) conventionally sintered Zolid fx white crowns, (ZS); speed sintered Zolid fx white crowns.

Each tooth was centrally embedded in epoxy resin block, and Standardized prepared using dental surveyor.

CAD-CAM work follow was applied to all the specimens, including: scanning, 3D designing, and milling of crowns.

All crowns were sintered using furnace (in-Fire HTC speed, Dentsply-sirona). Four different sintering protocols were applied according manufacture instructions of each subgroup.

Evaluation of marginal adaptation using silicon replica technique,each replica was measured at 25X power of magnification under stereo microscope.

One-way ANOVA test were used to detect significant differences which judged at (0.05) level.

Results: There was significant different between different zirconia materials (K and Z) with different sintering protocols (conventional and speed), at palatal finish line. The highest value of marginal discrepancy was at palatal finish line of (KS) subgroup (70.00±19.43 µm), while the lowest value was recorded at buccal finish line of (ZS) subgroup (45.00±9.71 µm).

Conclusions:1-The marginal adaptation of speed and conventionally sintered high translucent zirconia crowns were within the clinically accepted range.

2- Speed sintering protocol did not have harmful effect on the integrity of marginal adaptation of zolid fx crowns.

Introduction

Increasing demand from patients for natural appearing dental restorations has leaded to all ceramic restoration development, with continues improving of its mechanical and optical characters to insure clinical longevity. The introduction of dental zirconia high-lighted the true advancement of ceramic restorations because of its biocompatibility and mechanical properties.[1]

The clinical success of restorative dentistry has to consider the adhesion to different substrates, which has offered a great challenge to dental zirconia research and development.[2]

Zirconium oxide grains have spontaneous transformation from the (*t*) phase to the more stable (*m*) phase associated by volume expansion of 3%-5%, that could be exploited to enhancing the fracture toughness of partially stabilized zirconia. Volumetric expansion is restricted by the surrounding material, that induce compressive stress on crack tip, which stop cracks propagation, and prevent the failure of zirconia restoration. This is the reason why this phenomenon is called phase transformation toughening.[3]

The Y_2O_3 is the most widely stabilizer used in the content of 3 mol% for stabilization of the tetragonal phase, and 8 mol% for stabilization of the cubic phase of Y-TZP.[4]

The superior esthetics with long-term durabilityis the chief goal of zirconia development, among all of ceramic restoration the yttrium-stabilized tetragonal zirconia polycrystalline (Y-TZP) is one of the most interesting dental material. There are several variants of Y-TZP, depending on additives, sintering protocols, and heat treatments.[5]The main attraction is their mechanical properties, biocompatibility and resistance to corrosion, the greatest challenge is to produce them with sufficient esthetics to match natural dentition.[6]

The clear trend toward monolithic zirconia restorations to solve the problem of ceramic chipping and avoid excessive tooth preparation inevitable for placement of bi-layered zirconia ceramics, so the yttrium-stabilized tetragonal zirconia polycrystals (Y-TZP) has innovated as one of most best restorative choice with high esthetic and mechanical performance.[7]

The development of monolithic zirconia include some transparent phase in the final product to reduce opacity, this was achieved by using a higher yttrium content, 4mol\ (4Y-TZP) or 5mol% (5Y-TZP).The most translucent 5Y-TZP materials were indicated for usage as anterior crowns and anterior fixed partial dentures, but strength and toughness were diminished.[8]

Suleiman T. et al, 2016[9], studied the fracture rate of monolithic zirconia restorations, they conclude that a failure rate more than 2% over 5 years in the anterior zone.

Sintering process of zirconia is one of the most interesting fields of dental researches, The sintering temperature ranges from 1400°C-1600 C° (depending on manufacture instructions),sintering temperature and duration affects the crystalline microstructure and grain size, which have direct effect on properties of zirconia restorations.[10] Speed sintering of zirconia improves the productivity, and saving energy and time. Several researches were interested in studying the effect of speed sintering on monolithic zirconia, and they concluded that speed sintering and\or high sintering temperature have direct effect on micro crystalline structure as enlarged grain size of zirconia which affecting on flexural strength and translucency of monolithic zirconia restorations.[11,12]

One of the most important characters of successful zirconia restoration is superior marginal adaptation, so this study evaluated the effect of speed sintering on marginal adaptation of zirconia crown restorations. Poor marginal adaptation result in plaque retention causing cement dissolution and micro leakage that leading to caries and periodontal diseases that affect restorations longevity.[13]

CAD/CAM technology which depended on exact dimensional predictions has demonstrated improved marginal adaptation. The marginal discrepancy of each restoration can be evaluated by comparing the measurement values obtained at different steps of the manufacturing process.[14]

The evaluation of marginal adaptation of zirconia restorations can be observed by different methods.Clinically, marginal adaptation can be directly evaluated by dental probe and mirror with adequate magnification and illumination. Also, it is possible to cross section the master die or prepared tooth and the restoration for direct estimation of the space corresponding to cement gap under the microscope, but it is a destructive method.[15]

Micro computed tomography (micro-CT) allows high resolution images and permitting 2D and 3D visualization from any position or angle, it considered as non-distractive method but very expensive.[16]

Silicon replica technique considered to be one of the accepted non distractive methods used to estimate and study the marginal and internal adaptation of tow high translucent zirconia crowns.[17]

The null hypothesis of this study suggested that the speed sintering will not affect the internal and marginal adaptations of the high translucent zirconia crowns.

one of the defense cells of immune system with metachromatic cytoplasmic granules [25,26].

Recently,mast cells were recognized in the pathogenesis of more aggressive pathologic lesions [27]. Mast cells have an inhibitory role on the development of pathological lesions. However, stimulatory role of mast cells in the growth of pathological lesions is more prevalent and obvious than their inhibitory effect [28]. With respect to several roles of mast cells such as participation in inflammation, degradation of extracellular matrix and bone resorption[29], previous studies have identified mast cells in odontogenic cysts, but there were limited studies about the role of mast cells in the pathogenesis of odontogenic cysts [30]. There is a hypothesis that the more aggressive behavior of odontogenickeratocysts is related at least, partly, to distribution of mast cells. However, their pathogenesis and mechanism of expansion and enlargement have not been evaluated [31].

The aim of this study was to determine the density of microvessels and MCs in odontogenic cysts. Correlate the microvessel density with their corresponding mast cells density in the three types of cysts, in order to detect their possible role in the variable behavior of these odontogenic cysts.

Material and method :

A total of 20 human extracted maxillary premolar teeth were randomly divided into two main groups according to type of zirconia material used (n=10): group (K); teeth were restored with KATANA STML (125-3182, Kurary Noritak Dental Inc. Japan) crowns, and group (Z); teeth were restored with Zolid fx white (1910000, Amann Girbach AG, Austria).

Each group were further subdivided into two subgroups according to sintering protocols (n=5): (KC); conventionally sintered KATANA STML crowns, (KS); speed sintered KATANA STML crowns, (ZC) conventionally sintered Zolid fx white crowns, (ZS); speed sintered Zolid fx white crowns.

Each tooth was received two crowns, one conventionally sintered, the other was speed sintered. Finally we have 20 teeth and 40 crowns.

Each tooth was centrally embedded in epoxy resin block to Facilitates the preparation in assessment of dental surveyor (Marathon 103, New York USA). Preparation of all teeth was standardized to be 0.5mm chamfer finish line, 6° taper for each tooth wall, 1.5mm reduction for functional cusps palatal cusp), 1mm reduction for non-functional cusps (buccal cusp).[18]

CAD-CAM technology was applied, including scanning using (MEDIT T300 3D scanner, Seoul, Korea).The restorations were designed using (Medit linkV2.3.6, Seoul, Korea) software. After finishing the design of all crowns, and arranging them in the selected zirconia disc on computer screen. All data were transferred to the milling machine (Roland DWX-52D, Shizuoka, Japan). The final crown design of each specimen was duplicated to have two similar milled crowns, to applied different sintering protocol.

All 40 milled crowns were sintered in the same highly performance high temperatures furnace (inFire HTC speed-Dentsply Sirona, Germany). Each material provides speed sintering cycle according to there manufacture instructions.[19, 20]Each crown was seated on its corresponding prepared tooth, visually detectedfor any marginal discrepancies using magnified length**,** then all crowns from (K and Z) groups were glazed in (ivocolor Prgramat EP 3010 furnace-Ivoclar Vivadent).

The replica was fabricated using Low viscosity addition silicon impression materials with two different colors. First, light body (Prsigum, 290499,President Dental, Germany. orange color), and the second, light body(Ghenesyl light, 0269340110, LASCOD, Italy, blue color). The Thin layer of light body was representing a replica of the space between the abutment and the crowns. Each replica was cut buccopalatally into two equal halves using sterile blade (number 11), for evaluation buccal, and palatal margins. Second cut was made mesiodistaly for evaluation the mesial and distal margins.

Stereomicroscope (Olympus SZ61, Tokyo, Japan) was used to evaluate the marginal discrepancy of each replica at 25X power of magnification, **Figure (1)**

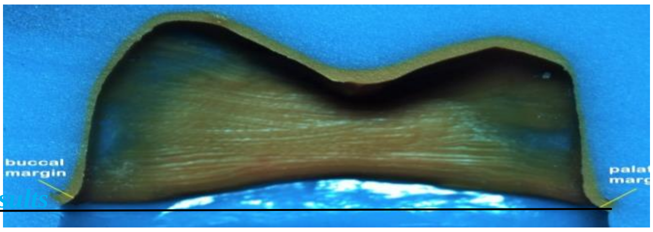

Figure (1): Silicon replica under microscope, showing points of palatal and buccal margin measurements

Results

One - way ANOVA test was used to compare between the marginal adaptations of all studied groups at different surfaces. It was showed that significant difference at buccal finish line between all the studied subgroups (KC, KS, KS, ZS) (p=0.004), (p<0.05), as showed in Table (2) was for (ZS) subgroup (45.0±9.72).

Table (2): One - way ANOVA test comparing marginal adaptation (µm) between all studied groups at different surfaces.

	KATANA conventional sintering (KC)	KATANA speed sintering (KS)	Zolid fx Conventional sintering (ZC)	Zolid fx speed sintering (ZS)	Test of significance
	N=10	N=10	N=10	N=10	
Buccal finish line	61.0±8.76[ab]	59.0±11.01[c]	51.0±11.01[a]	45.0±9.72[bc]	F=5.29 P=0.004*
Palatal finish line	57.0±14.94	70.0±19.44	65.0±14.34	54.0±9.66	F=2.385 P=0.085
mesial finish line	55.0±12.69	59.0±12.87	68.0±21.49	67.0±18.89	F=1.382 P=0.264
Distal finish line	55.0±11.79	68.0±10.33	60.0±15.63	67.0±19.47	F=1.734 P=0.177

F: One - way ANOVA test
Parameters described as mean ± SD
***Statistically significant (if p<0.05)**
Similar superscripted letters denote significant difference v=between groups within same row by Post Hoc Tukey test.

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Discussion:

This in vitro Study evaluated the influence of different sintering protocols on marginal and internal adaptation of two different high translucent zirconia crown restorations.

In accordance to the results of this study, the null hypothesis was partially accepted, as the speed sintering improve the internal adaptation of ZS subgroup, while the speed sintering decrease the marginal adaptation of KS subgroup.

The assessment of the internal and marginal adaptation was performed on human natural extracted maxillary premolars to simulate the actually clinical conditions as possible, selective collection of teeth with comparable sizes and shape and ensure that by using digital caliper.

Silicon replica technique considered to be one of the accepted non distractive methods used to estimate and study the marginal adaptation of tow high translucent zirconia crowns, and one of the most convenient, easy, and rapid method of measurements.[17]

LI L. et al, 2019.[21]studied the marginal discrepancy of monolithic zirconia crowns, there was ranged between (46 µm -110 µm). **Cunali R. et al, 2017.**[22] studied the marginal adaptation of zirconia crowns, there were ranged between (68 µm -77 µm).

The descriptive statistics of marginal adaptation (µm) among all the studied groups showed that; The highest value of marginal discrepancy was at palatal finish line of (KS) subgroup (70.00±19.43 µm), while the lowest value was at buccal finish line of (ZS) subgroup (45.00±9.71 µm). This values of marginal discrepancies considered in the clinically accepted rang (50-120 µm) according to Holmes.[23] While more restrictive studies proposed marginal discrepancy must be less than 100 µm.[13]

The results of this study showed that, there were significant differences in marginal adaptations between both crown restorations materials (K and Z) and sintering protocols (conventional and speed) at buccal finish lines. This could be attributed to the increase of sintering temperature of KATANA (1560°C) more than Zolid fx (1450°C). The high sintering temperature lead to Zirconia creep, which depended on both temperature and stress, the zirconia creep rate increase with increasing temperature, that may be explained the high marginal discrepancy value of (KS).

It was believed that, the narrow surface area of thinner crowns (like the 0.5 mm chamfer finish line) more sensitive to the creep effect.[24]

Studying the effect of sintering protocol on margin adaptation of both materials (K and Z) showed that, there is no significant effect of sintering protocol on margin adaptation of (Z) group. But, there was a significant effect of sintering protocol on margin adaptation of (K) group, as (KS) recorded higher marginal adaptation values (68.0±10.33) than (KC) (55.0±11.79), that may be attributed to the effect of high heating rate of speed cycle of [(KS) 35°C / min], while the heating rate of [(KC) was 10°C / min].

The results of this study was in agreement with the results of **Ahmed W. et al, 2019.**[24] Who study the influence of sintering protocols on marginal discrepancies of monolithic zirconia crowns, and showed that, there was a significant effect of sintering protocol on marginal discrepancies of monolithic zirconia crowns as a smaller marginal discrepancies were observed for conventionally sintered zirconia crown preparations with a 0.5 mm finish line and 1.5 mm occlusal reduction.

The contrasting of these studies result may be attributed to the different zirconia materials used, parameters of sintering protocols and other methodological differences between this study and other previous studies.[13, 21]

Limitations

To provide guidelines for clinical practice, it is important to recognize the limitations of the currently used techniques in this study:

1-The results of this study cannot generalize on all zirconia brands, as we only study two types of zirconia material. Each brand has different properties and behavior under different sintering protocols.

2- In this study we do not cement the crowns, or applied the crowns to thermal cycling loading, that may be not mimic the actual intra oral conditions.

Conclusion:

Based on the results and within the limitations of this study the following conclusions are:

1- The internal and marginal adaptation of speed and conventionally sintered high translucent zirconia crowns are within the clinically accepted range.

2- Speed sintering protocol did not affect the integrity of marginal adaptation of zolid fx crowns.

3- The internal and marginal adaptation of speed sintered Zolid fx crowns was significantly lower than KATANA speed sintered crowns.

Recommendation:

KATANA zirconia crowns can be speed sintered at (1560°C) for 90 min, and achieved acceptable internal and marginal adaptations, which are feasible for one visit appointment. So we recommended the clinical application with following up of KATANA speed sintered zirconia restorations.

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