Evaluation the Effect of Different Thicknesses Core on the Micro-Hardness of Zirconia Ceramic Material

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Abstract

All-ceramics have been increasingly used in prosthetic dentistry to fabricate a wide variety of restorations [1] The most recently core materials are the yttrium oxide partially stabilized zirconia (Y-TZP), were found as a new material for all dental ceramic restorations Partially stabilized yttria tetragonal zirconia polycrystalline (Y-TZP) ceramics are a relatively new class of dental ceramics introduced to the market. that are made into blanks and milled to the favorite dimensions using the CAD/CAM (Computer Aided Design/Computer Aided Manufacturing) technology.

Objective: To evaluate the effect of different thicknesses on the hardness of disks fabricated by the yttrium oxide partially stabilized zirconia (Y-TZP)**.**

Method: This quantitative study was conducted to assess and evaluate the surface hardness of disks in terms of fabrication thirty disc-shaped of wax pattern were prepared in three core thicknesses materials (0.5 mm, 1mm and 1.5 mm), and each all-ceramic system with a 10 mm diameter were prepared according to ISO specification 6872 Vickers diamond indenter was utilized in accordance with micro-hardness tester.

Result: The hardness of tetragonal yttrium partial stabilized zirconia with different thicknesses (0.5,1 and 1.5) mm, were as follows:

The mean value of 1mm thickness (2557.2967) is greater than mean value of 0.5 mm (2240.4433) in a high significant amount (H.S), and also greater than mean value of 1.5mm (2520.3600) in a significant amount.

So, the partially stabilized zirconia specimens with 1mm thickness has better hardness than 1.5mm and 0.5 mm thicknesses.

Conclusion: The results concluded that the tetragonal partially stabilized zirconia displays a higher surface hardness for thickness with 1mm than the specimens with 0.5 mm and 1.5mm thickness with the same materials.

Keywords: Hardness tes,yttrium partially stabilized zirconia,Vicker micro hardness test Machine

تقييم تأثير اختلاف السمك على صلادة السطح لمادة الزركونيا المستخدمة في صناعة الاسنان الصناعية

نورس عدنان محمد و أ.م.ايهاب نافع ياسين

الخلاصة

الهدف : لتقييم تأثير سـمك مختلفة على صـلابة الأقراص المصـنوعه من مادة الزركونيا الشـائعه في صـناعة الاسـنا ن الصناعية

الطريقة: أجريت هذه الدراسة الكمية لتقييم صلابة السطح للأقراص من حيث التصنيع تم تحضير ثلاثين قرصًا على شكل شمع في ثلاث مواد بسماكة أساسية (0.5 مم ، 1 مم و 1.5 مم) ، ولكل نظام سيراميك كامل بقطر 10 ملم تم ISOبقطر 10 ملم تم تحضيرها طبقًا لمواصفات ISO 6872 تم استخدام إندينتر الماس فيكرز وفقًا لاختبار الصلابة الدقيقة Iso .

6872طبقًا وتم تحضيرها لمواصفات تم استخدام إندينتر الماس فيكرز وفقًا لاختبار الصلابة الدقيقة

النتيجة: كانت صلابة الإيتريوم رباعي الزركونيا المستقر الجزئي بسماكة مختلفة (1،0.5 و 1.5) مم ، كما يلي:
القيمة المتوسـطة بسـمك 1 مم (2557.2967) أكبر من القيمة المتوسـطة البالغة 0.5 مم (2240.4433) بكمية كبيرة عالية (H.S) ، وأيضًـا أكبر من القيمة المتوسـطة 1.5 مم (2520.3600) بكمية كبيرة. لذلك فأن عينات الزركونيا المستقرة جزئياً بسمك 1 ملم لديها صلاده أفضل من سمك 1.5 مم و 0.5 مم.

الخاتمة: خلصت النتائج إلى أن الزركونيا المستقرة جزئياً تظهر صلابة سطحية أعلى للسمك بسمك 1 مم عن العينات ذات السماكة 0.5 مم و 1.5 مم بنفس المواد

الكلمات المفتاحية:قوة الصـلاده, مادة الزركونيا الكاملة االمصـممة باسـتخدام الحاسـوب و المصـنعة بواسـطة ماكنة الحفر الالي,جهاز فيكر لأختبار الصلادة المايكروية.

Introduction

Zirconia material is a polymorph substance that occurs in 3 phases: monoclinic (M), (from room temperature (up to 1170°C), tetragonal (T) (1170°C to 2370°C) and finally cubic (C) (above 2370°C) [1,2]. It achieves better behavior in the tetragonal form [3]. However, the most stable phase at room temperature is monocyclic and the use of oxides to stabilize zirconia in the tetragonal form at this temperature become more necessary [1,2]. The addition of stabilizing oxides like CaO, MgO, CeO2, and Y2O3 to pure zirconia allows the creation of metastable materials known as Tetragonal Polycrystalline Zirconia (TZP) [2]. Y-TZP zirconia has been used as the framework of all-ceramic crowns and fixed partial dentures, implants, abutments, and brackets. Many studies demonstrated that in several cases the light reflection from the opaque metal structure compromises the natural appearance and the outcome of restoration break down [3]. So, new ceramic materials have been developed to implement the patient's need and to accomplish them with similar natural tooth translucency [4].

Among different ceramic systems, zirconia-based ceramics are take into account to be more adequate and engaging in the eyes of dentists [5] Zirconia based ceramic material tend to provide biomechanical properties, and because of the enhancement in the crystalline content, the strength and opacity of all-ceramics increases [6]. Cors of zircon when compared to other, all-ceramic systems have poor translucency and are extremely white in manifestation [7,8]. Y-TZP zirconia is considered the most compatible material to hold out the high stress on the posterior all-ceramic bridges, being convenient for the manufacture of frameworks having more than five elements. Among its properties, zirconia exhibits high Vickers hardness around 1300VHN3,5 and must comply with criterion F1873 of the American Society for Testing and Materials (ASTM), that suggests values above 1200HV3.the Hardness testing has many pitfalls and good metrological procedures it is one of the most frequently measured properties of ceramic. Hardness value helps to characterize resistance to deformation, densification, and fracture it measured by conventional microhardness machines Vickers diamond indenters. So, the aim of this study was to assess the hardness with different thickness of disks fabricated by the yttrium oxide partially stabilized zirconia (Y-TZP)**.**

Material and method

Procedures was done by CAD/CAM machine to be efficient and satisfying patients need in terms of dental restoration. thirty disc-shaped samples were Divided into three groups of 10mm diameter, first group contains ten samples of 0.5mm thickness and the second group contains ten samples of 1mm thickness and the third group contains ten samples of 1.5mm thickness, all of groups had been designed in accordance to the manufacturer's recommendations. Yetterium partially stabilized zirconium oxide discs with thicknesses 0.5, 1 and 1.5 mm and10 mm in diameter were fabricated by milling pre-sintered KT13 zirconium blocks (94.4% ZrO_2, 5.4% Y_2O_3) according to the manufacturer's instructions with the Dental Wings CAD/CAM system. The zirconium blocks were machined with 1.3 mm in diameter diamond burs in the CAM unit. All machined discs were designed 20% larger than the desired size to compensate for sintering shrinkage as shown in figure (1).

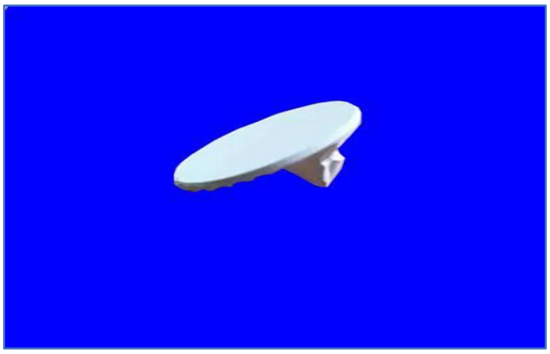

Figure (1): Yttrium partially stabilized zirconia sample before finishing procedure

After the milling process, the disc-shaped specimens were smoothed with stone bur before firing as shown in figure (2).

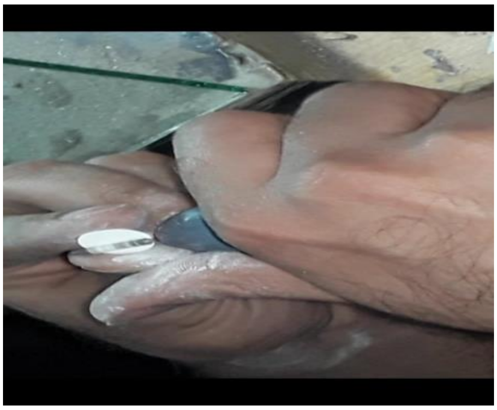

Figure (2): Smoothing the samples with stone bur before firing procedure.

After that, the samples were sintered at 1,400°C for 14 hours according to the manufacturer's instructions then samples fabrication procedure was completed [9] and as shown in figure (3).

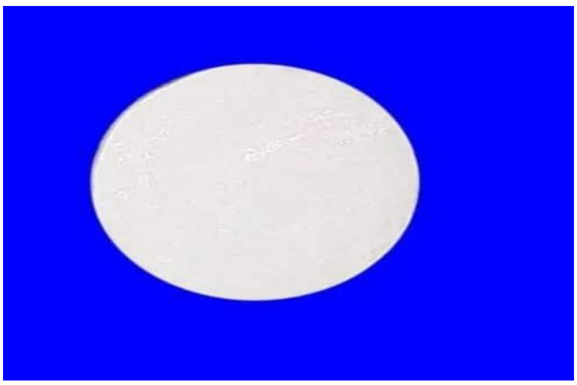

Figure (3): Yttrium partially stabilized zirconia samples after firing procedure.

The surface hardness were measured using Vickers Hardness Tester (Model VHS-50, Laizhou Huayin Testing Instrument Co Ltd. China). The tested sample was mounted in the horizontal stage of the tester then the indenter was lowered under a load of9.8N for 15 seconds. The indentations of hardness test were measured currently after the automatic return back of the indentor [7]. For each tested sample, Readings was done by measuring the size of the diagonals of the indentation immediately in Vickers. For each tested sample, all indentations were measured and an average Vickers micro hardness number HV was determined [7,8].

Result

The results of this study were analyzed statistically using SPSS version 22.0 and analysis of variance (ANOVA) with LSD Test.

Micro-Hardness Test Results

Means and standard deviations of the ceramics micro-hardness values for the tested groups are presented in table (1) and figure (4). A one-way ANOVA Test was used to determine significant differences among the tested samples ($p < 0.05$).where the samples of partially stabilized zirconia with 1mm thickness show higher micro-hardness values than samples with 1.5mm ,So according to the mean values of 0.5 mm which is 2240.4433, mean value of 1mm sample which is 2557.2967 and the mean value for 1.5 mm which is 2520.3600, we got that the partially stabilized zirconia with 1mm thickness the best hardness when compared with 1.5mm and 0.5 mm thicknesses' specimens.

Table (1): Mean and Std. Deviation of hardness in all zircon samples groups in relative different thicknesses.

Groups	N	Mean	Std. Deviation
Zircon 0.5mm	10	2240.4433	365.47729
Zircon 1mm	10	2557.2967	312.41922
Zircon 1.5mm	10	2520.3600	265.13877

Table (2): ANOVA distributions of hardness in all zircon samples groups with relative different thickness.

(I) Material Z	(J) Material Z	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval		Sig.
					Lower Bound	Upper Bound	
Zircon 0.5mm	Zircon 1mm	-316.8533*	81.85054	.000	-479.5401	-154.1665	HS
	Zircon 1.5mm	-279.9167*	81.85054	.001	-442.6035	-117.2299	S
Zircon 1mm	Zircon 1.5mm	36.9367	81.85054	.653	-125.7501	199.6235	NS

(*) S: Sig. at P<0.05; NS: Non Sig. at P>0.05 ; HS: High Sig.

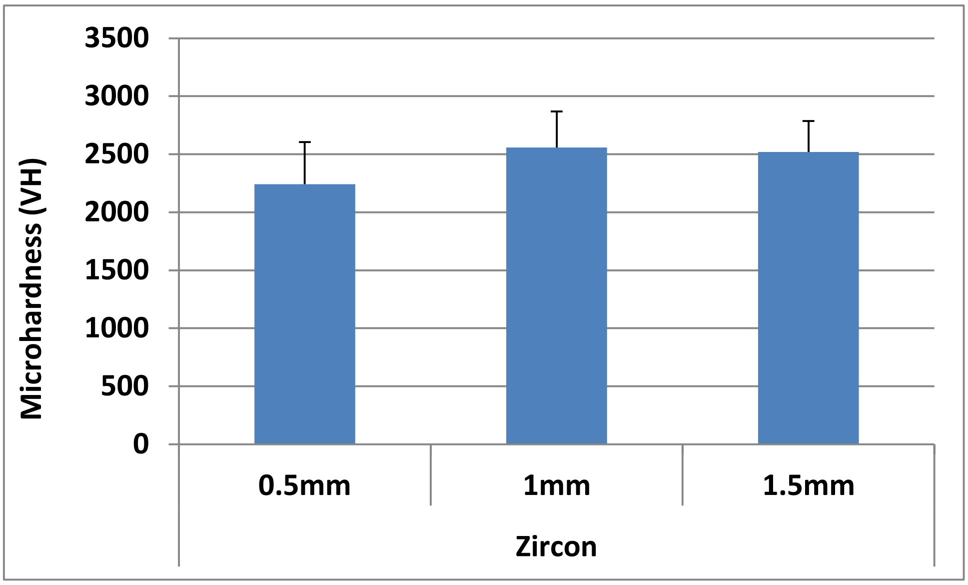

Figure (4): Bar- chart showing the hardness of all zircon samples groups

Discussion

The use of monolithic zirconia has become a topic of interest for the restoration of severely damaged teeth, mainly because the high incidence of chipping or cracks within the veneer layer can compromise the longevity of the bi-layer [9].

The application of zirconia in monolithic configuration is possible because of the high surface hardness of the material combined with improved translucency [10]. Yttrium-partially stabilized zirconia polycrystal (Y-TZP) referred to as pure zirconia without metal dental restorations are one of the most desirable treatments for teeth requiring indirect restorations, given zirconia's biocompatibility, white color and high mechanical properties [11]. Zirconia has been the material of choice for frameworks need restorations as opposed to metal, so because of its whitish and opaque color the coping needs to be veneered with porcelain, and these restorations are frequently referred to as bi-layer restorations [12**].**

The application of zirconia in monolithic configuration is possible because of the high surface hardness of the material combined with improved translucency [13,14]. The results of the present study indicate that the Several properties of this material are related to its hardness as strength, proportional limit, and ductility. Indentation hardness testing is a convenient method of distinguish the mechanical properties of a small volume of samples. In spite of differences in the geometry of the indenters that are used in hardness testing, the Vickers indenter is one of the most widespread use[15].it is one of the most frequently measured properties of all ceramic materials. hardness value helps to describe resistance to densification, deformation, and fracture which is usually measured on conventional microhardness machines by Vickers diamond indenters. Hardness measurements were done by using a Time Instrument HV 1000 Vickers Micro-Hardness Tester.Which was conducted on the polished surfaces of the specimens using a Vickers diamond pyramid at different peak contact loads. The Vicker Hardness Test was selected because it is perfect for determining the hardness of small areas as used by the different investigator [16].

The result of the present study explain that full contour zirconia showed significantly higher mean Vickers's hardness.Values of Vickers hardness are measured under load 9.8N which is show zirconia ceramic has superior mechanical properties, the mean surface hardness of the samples with 0.5 mm is. 2240.4433 and it is statically non-Significant when compared with the mean value of samples 1.5mm which was 2557.2967 and it is statically significant and finally when compared the first samples with 1mm thickness the samples the mean value of last group samples is 2557.2967 which it is statically highly significant because of zirconia phase transformation toughening mechanism that prevented crack propagation in the outer surfaces of these material the mechanism of the zirconia material involved the transformation from tetragonal to monoclinic phase **(**t-m**)** at the crack tip and around the crack by localized compressive stress, this was in agreement with the results of Passos et al[17] and Mostafa et al [18].

Conclusion

The results concluded that the tetragonal partially stabilized zirconia displays a higher surface hardness for thickness with 1mm than the specimens with 0.5 mm and 1.5mm thickness with the same materials.

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