Evaluation of thickness of CAD/CAM fabricated zirconia cores by digital microscope

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Abstract. Despite several advantages of digitalized workflow, researchers have noted discrepancies in the precision and true-ness. This study investigated the accuracy in the final thickness of Zirconia (Zr) cores fabricated by five CAD/CAM systems. Standardized manufacturing of the cores with 1 mm thickness were carried out. Cores were then sectioned into two halves and measurement made with Digital Microscope at 5 points in micrometers. Overall, mean thickness for the groups was 1048.81 ± 94.01, which was 48 μm higher than the thickness programmed in the software. Anova showed a statistically significant difference between the groups (p = 0.000). Presence of variations in the thickness and 5 measurement points for the CAD/CAM systems investigated was found. No significant difference was observed and the thickness of the cores were within acceptable level.

Keywords: Zirconia, zirconia core, zirconia copings, CAD/CAM, zirconia crowns

1. Introduction

All ceramic restorations have been in use for decades to restore compromised, heavily restored teeth and primarily for aesthetic improvements. It has been difficult to find a material that satisfies the requirements for both strength and aesthetics. To provide high strength and improved esthetics, zirconium oxide has been used as a core material. The yttrium oxide partially stabilized tetragonal zirconia (Y-TZP) stands out for meeting such requirements of a high strength core material. The fabrication of Zr cores involves CAD/CAM technology which requires only few steps for the fabrication of a restoration compared to the old traditional methods [1,2].
The recommended thickness of the Zr core ranges from 0.3 mm to 1 mm [3]. The thickness of the Zr core has been related directly to its strength, esthetic outcome, marginal integrity and the bonding of the ceramic veneer [4]. Despite several advantages of digitalized workflow in the fabrication of CAD/CAM Zr cores, discrepancies in the precision and trueness have been noted by researchers. The sources of inaccuracy can come from the data acquisition, CAD software or can arise from milling and 3D printing [5].

The purpose of this in vitro study was to investigate the accuracy in the final thickness of five different CAD/CAM fabricated Zr cores by measurements with a digital microscope. The null hypothesis was that no significant difference will be found between the virtual thickness set in the software and the actual thickness after the fabrication of Zr cores with different CAD/CAM systems.

2. Methods

A scannable ivorine tooth (Lower right first molar) mounted in resin base (D85DP-CHO.1, Nissin Dental Products, Inc., Kyoto, Japan) was prepared with ideal parameters of chamfer margin (1 mm), taper (6–10 degrees), occlusal reduction (2 mm), axial reduction (1 mm), bevel of the functional cusp and smooth rounded finish for Zr crown [6]. The prepared tooth was scanned and 100 identical resin dies were fabricated by 3-D CAD/CAM laser printing (DWX-50, Roland, USA). Specimens were divided into 5 groups of 20 each (A: Ceramill Motion2, Amann Girrbach, Germany; B: Weiland, Ivoclar Vivadent, USA; C: Cerec, Sirona Dental, USA; D: Zirkonzahn, Gmbh Bruneck, Italy; E: Cad4dent, Canada). All the dies were scanned and Zr cores were digitally designed with compatible softwares of the systems with standardized thickness of 1 mm. The designing information was sent to milling machines of each system for milling of cores from Zr blocks recommended by the systems. After milling the copings were sintered, cooled, tried on their respective dies, examined visually and tactically with a sharp explorer for marginal integrity. Specimens which were found to have marginal discrepancies were rejected and not included for further processing. To avoid the breakage of the cores during sectioning the specimens were embedded in resin. With manual surveyor (Dentalfarm Manual Surveyor, A3005, Italy) a vertical load of 20 Newtons was applied over the coping and the complete specimen was embedded with resin (Ortho-Resin, DeguDent GmbH, Germany). Once the resin was set the specimens were cut into two halves using automatic saw (Isomet-2000 Precision Saw, Buehler, USA). The thickness of the specimens...
Fig. 2. Diagrammatic representation of the 5 points measured. (a: Buccal Marginal Thickness; b: Buccal Axial Thickness; c: Occlusal Thickness; d: Lingual Axial Thickness; e: Lingual Marginal Thickness.)

were measured at 5 points in micrometers at 50x magnification with Digital Microscope (HIROX, KH 7700, Tokyo, Japan) using software program (KH-7700, Ver.2.10©Hirox Co. Ltd. 2010). The digital microscopic measurements from the two pieces for five points of each specimen were recorded and their mean was calculated and used as final reading for that specimen (Fig. 2).

3. Results

The minimum and maximum thickness in µm of 948.20 ± 69.75 and 1130.12 ± 75.74 were for Group D (Zirkonzahn GmbH, Bruneck, Italy) and Group A (Ceramill Motion 2, Amanngirrbach, Germany), respectively. The overall mean thickness in µm of all the experimental groups was 1048.81 ± 94.01, which was 48 µm higher than the thickness programmed in the software. With the univariate analysis of variance test showing a statistically significant difference between the groups (p = 0.000). The results of Post Hoc Scheffe’s test for multiple comparisons revealed no significant difference between Group C and Group E (p = 0.999), while the rest of the experimental groups had significant differences (p = 0.000) between them.

It is evident from the line graph (Fig. 3) that least variation existed for experimental Groups A and B while the highest variation was observed for Group D. The multiple comparison with Scheffe test also confirmed the observation as no statistically significant difference (p > 0.05) was found between the five points of measurements for the Groups A and D.

4. Discussion

Based on the results of the current study, the null hypothesis was rejected. The results indicated that the virtual thickness of 1 mm (1000 µm) set in the software program for all the systems differed from the actual measurements and variation for thickness was present between the different systems tested. According to the results a trend of an increase in the thickness (> 1 mm) was observed for all the groups except for Group D (948.20 ± 69.75 µm). Only Group B (1002.41 ± 58.13 µm) was found to have almost the same thickness as set in the software.
CAD/CAM technology has already changed dentistry. However, the existence of errors in the digital workflow is reported in several research studies [7,8]. The sources of inaccuracies in the final restorations can come from the data acquisition (scanners), transformation error from data acquisition to the software and milling or 3D printing of the restoration [9]. Koch et al. [5], in a recent study reported the variations in the milled models resulting from software and scanner error. In a study of comparison between digital impression cast fabrication and conventional impression cast fabrication, Cho et al. [9] reported superior accuracy and reproducibility of the complete arch casts by the conventional cast fabrication method.

Despite all positives aspects of all ceramic restorations compared to metal ceramics the restricted depth limits the veneer thickness and making it prone to fracture under masticatory loads [10]. Based on the results of the current study variation existed in the thickness of the Zr core from as low as 0.824 mm to 1.408 mm. This variation in the thickness in the Zr core may result in a decrease or increase in the thickness of the veneering ceramic layer and ultimately leading to the failure of ceramic. Su et al. [11] has reported that CAD-CAM Zr has a relatively high Weibull modulus which implies high reliability and a Zr core with homogenous structure. On the other hand veneering materials such as porcelain has as lower Weibull modulus because of the conventional powder and liquid fabrication or manual technique resulting in less homogenous material. This difference may result in the production of radial cracks within the veneering ceramic that can propagate further [11].

Marginal adaptation of all ceramic Zr crowns is also affected by the thickness of the underlying Zr core. Jalalian et al. [12], in a recent study concluded that increasing the Zr core thickness can decrease the marginal gap in all ceramic Zr crowns. Unlike metal copings for metal ceramic restorations, manual finishing of milled Zr cores for adjusting the thickness result in damage to the core and increasing the susceptibility to aging. Daou [13], reported that grain pullout and micro cracking as well as decrease in strength of the Zr as consequences of this aging process.

5. Conclusions

Presence of variations in the thickness of the Zr cores fabricated by different CAD/CAM systems investigated in the study was found. However, no significant difference was observed for the difference
in thickness between the systems tested. Cores fabricated with Weiland (Ivoclar Vivadent, USA) were found to have almost the same thickness as programmed in the software. Difference in thicknesses were observed for the five measurement sites for all the groups tested. The thickness of the cores for all the five groups tested were within the acceptance level.

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Conflict of interest

None to report.

References