

Dual-scan technique for the customization of zirconia computer-aided design/computer-aided manufacturing frameworks

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ABSTRACT

The use of bi-layered all-ceramic crowns has continuously grown since the introduction of computer-aided design/computer-aided manufacturing (CAD/CAM) zirconia cores. Unfortunately, despite the outstanding mechanical properties of zirconia, problems related to porcelain cracking or chipping remain. One of the reasons for this is that ceramic copings are usually milled to uniform thicknesses of 0.3-0.6 mm around the whole tooth preparation. This may not provide uniform thickness or appropriate support for the veneering porcelain. To prevent these problems, the dual-scan technique demonstrates an alternative that allows the restorative team to customize zirconia CAD/CAM frameworks with adequate porcelain thickness and support in a simple manner.

Key words: Computer-aided design/computer-aided manufacturing, dual-scan technique, zirconia

INTRODUCTION

For decades metal ceramic restorations have been considered the “gold standard” treatment for the fabrication of prosthetic crowns and fixed partial dentures (FPDs).^[1] Ceramic materials with different processing routes were developed to play this role without the inherent disadvantage of a metal framework.^[2]

At first, the main drawback with the use of all-ceramic crowns was bulk fractures due to the brittle nature of ceramics and the lower mechanical properties when compared with metal frameworks.^[3] The advent of computer-aided design/computer-aided manufacturing (CAD/CAM) technology allowed the possibility of working with high strength polycrystalline materials, shifting the problem to the veneering ceramics.^[3-6] This seems reasonable since the veneering ceramics present lower flexural strength (90-120 MPa) compared with the yttria-stabilized tetragonal zirconia polycrystals substructure (900-1200 MPa).^[7,8] This way, the use of glass-ceramic ingots for pressing veneering

ceramics onto zirconia frameworks was proposed to reduce the prevalence of veneer chippings/fractures. However, attempts to improve the microstructure and mechanical properties of veneering ceramics did not result in increased reliability.^[9,10] In addition, identical chipping failure patterns were observed.^[9-12]

Despite the numerous advantages of CAD/CAM technology, it seems that at some point clinicians and laboratory technicians started paying less attention to basic principles of substructure design in fixed prosthodontics. This article describes an alternative technique for the customization of CAD/CAM frameworks through a dual-scan process. This procedure provides adequate porcelain support and thickness in a predictable manner with little additional effort and cost to both clinicians and laboratories.

CASE REPORT

A 46-year-old woman, presented with a carious lesion under a metal onlay restoration on tooth number 16 requesting an esthetic restoration. The patient had

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excellent oral hygiene and a low caries rate. She was advised of the available metal ceramic and all-ceramic options before selecting a zirconia-based all-ceramic crown.

First, a full-contour waxing of the final restoration was made to guide all clinical and laboratory steps. The waxed tooth was molded with addition silicone twice. One mold was cut mesiodistally and was used to guide tooth reduction. The other uncut was used to fabricate the temporary restoration with bis-acrylic resin (Protemp 4, 3M ESPE, St. Paul, MN, USA). Tooth preparation was carried out leaving 1.5 mm of space for the final restoration in the axial walls and 2.0 mm in the occlusal area [Figure 1]. A chamfer preparation was chosen since the scanning device can easily read it. The temporary restoration corresponded to the patient and dentist's expectations functionally, biologically and esthetically.

Commonly CAD/CAM systems deliver a uniform substructure ranging from 0.3 mm to 0.6 mm in thickness. The software provides uniform substructure width, but the restorations end up with an extensive and non-uniform space for porcelain application over the zirconia framework, being more prone to chipping and cracking. In the technique described in this article, waxing cut back was performed to obtain uniform and adequate porcelain thickness [Figure 2]. This way, substructure thickness is not uniform, but the zirconia substructure provides support for the overlying porcelain. The only difference to a metal ceramic substructure is that there is no palatal/lingual collar since zirconia exposure to moist environments may be detrimental to its performance. Hence, what needs uniformity in thickness is the porcelain and not the zirconia substructure.

A dual-scan procedure was used to combine the datasets from the die with and without the waxed

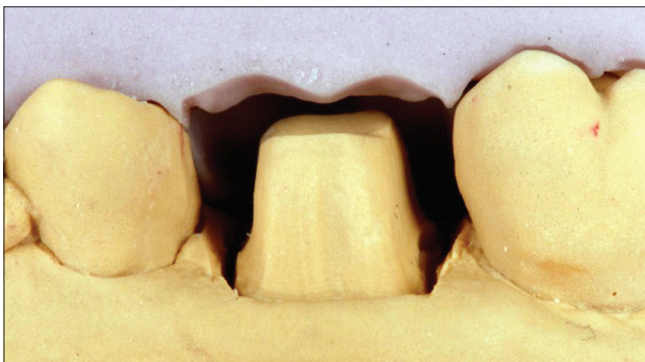


Figure 1: Prepared tooth

substructure. First, the die was scanned. Then, the wax pattern was sealed to the die, which was scanned a second time. The scanner (Circon Eye; Dentsply USA) used the sub marginal data points to orient the two scans and merge the data sets. It works as a subtraction of the images: The die with the waxed substructure minus the die with the tooth preparation. The result of this image subtraction is the personalized substructure for that specific case [Figure 3]. The merged file was transmitted to a milling facility and the coping was manufactured [Figure 4]. The porcelain veneering (Circon Ceram, Dentsply, USA) was completed [Figure 5] and the crown cemented (RelyX Unicem, 3M ESPE, St. Paul, MN, USA) after surface treatment with sandblasting and alloy primer application. This particular restoration has been in service for over 1 year without clinical complications.

DISCUSSION

The chipping problem is the most frequent reason for failures in all-ceramic zirconia restorations, irrespective of the zirconia veneer system applied. Veneer fracture rates are reported at 2-9% for single crowns after 2-3 years and at 3-36% for FPDs after 1-5 years. Implant-supported zirconia-based restorations revealed even higher rates at 8% for single crowns after 6 months and at 53% for FPDs after 1 year. Impaired proprioception and rigidity of osseointegrated implants associated with higher functional loads might further aggravate cohesive veneer fractures.^[13]

Persuasive literature exists pointing to thermal processing problems as a possible cause of residual stress and defects (too rapid heating and cooling given the very low thermal conductivity of zirconia). However, chipping seems to be a phenomena not limited to zirconia restorations and also related to



Figure 2: Waxed substructure

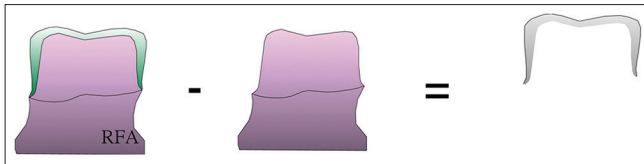


Figure 3: Dual scan technique. This procedure works as if a subtraction of the images is made: The die with the waxed substructure minus the die with the tooth preparation. And the result of this image subtraction is the customized framework for that specific case ready to be milled from zirconia blocks



Figure 5: Ceramic crown after porcelain application

the design of the substructure. The design of the substructure especially with the launch of CAD/CAM generated zirconia restorations provided no support for the veneering ceramic. Ceramic copings are often uniformly milled to thicknesses of 0.3-0.6 mm. This lack of porcelain support may have contributed to the actual high numbers of chipping on FPDs as opposed to failures on the interface between substructure and veneering alone as supposed earlier.^[3,14,15]

The lack of a uniform layer of the veneering ceramic because of improper framework design has been discussed as a possible reason for chipping fractures. Few clinical data on optimal design of zirconia-supported restorations have been published.^[16-18] With the introduction of CAD/CAM technologies in dentistry, excessive veneer layer thickness (>2.5 mm) was created because of the uniform layer thickness of the copings for crowns and bar-shaped connectors for FDPs. Improved customized zirconia coping design derived from the conventional porcelain fused to metal technique has been recommended to provide adequate support for the veneering ceramic.^[14] A dual-scan procedure of the die and full-contour wax pattern has been merged to customize the desired framework. Preliminary *in vitro* studies showed that cohesive fractures within the veneering ceramic could not be avoided with the improved support, but the size of the fractures decreased significantly^[18,19] and



Figure 4: Milled zirconia substructure identical to the waxed substructure

failure initiated at higher loads.^[11] Hence, the effect of framework design modifications on residual stress states needs to be better elucidated.^[20]

CONCLUSIONS

This technique represents an option to traditional single scan CAD/CAM framework fabrication. It allows for the individualization of the substructures in a predictable manner and possibly improves longevity of all-ceramic crowns since core and porcelain thicknesses can be controlled.

Appropriate porcelain and core thickness may decrease internal stress and reduce mechanical failure.

This technique needs to be further studied in a controlled clinical trial to determine the effectiveness of substructure modification.

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