Technical Report

Effect of Veneering Techniques on Ceramic Fracture of Zirconia Restoration

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Abstract

All-ceramic prostheses are increasingly being fabricated along with advancement in dental material science, the demand for non-metal prostheses, and the introduction of zirconia. However, problems have occurred following the prevalence of zirconia application. Although zirconia fracture is rarely seen, the risk of veneer ceramic fracture is rather high. Reducing this risk has therefore become an important issue for manufacturers. Given that the conventional hand-layering technique may partly account for veneer ceramic fracture, new techniques have been developed: press-on technique, CAD/CAM veneering technique, and use of full zirconia restorations. However, all of these techniques require further examination through long-term studies.

Keywords: **CAD/CAM, fracture, pressed ceramics, veneer ceramics, zirconia.**

With advancement in dental material science and the development of zirconia, all-ceramic restorations are increasingly being used clinically. Zirconia has good mechanical properties, making it suitable as material not only for anterior crowns but also for posterior crowns and bridges. However, problems have occurred because of the prevalence of zirconia application. Although zirconia fracture is rarely seen, the risk of veneer ceramic fracture is rather high. Reducing such risk has therefore become an important issue for manufacturers. This article presents a review of related studies on methods of preventing veneer ceramic fracture.

The history of zirconia dental application is not quite long, especially for bridge fabrication. Hence, most zirconia-related clinical reports are limited to short-term follow-up results. In addition, significant variation exists in reports on veneer ceramic fracture, with some reports revealing no veneer ceramic fracture at all and others showing fracture rates more than 50%. The variation also indicates that the fabrication of zirconia restorations might be very technique sensitive.[1–3] There are many factors causing veneer fracture, such as insufficient veneer strength, inexperience with new ceramics, mismatch in the coefficient of thermal expansion, insufficient framework support, near-surface damage, and sliding contact fatigue.[4–12]

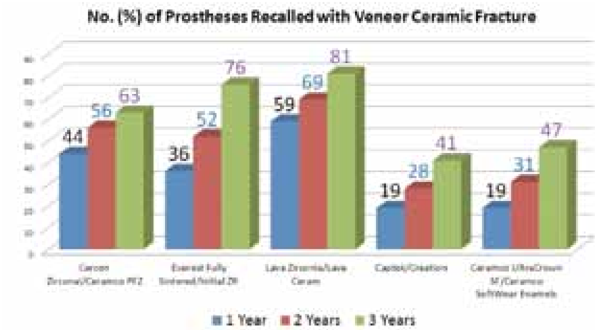

Fig1 Veneer ceramic fracture rate of 3-unit bridge with hand-layering technique: All of the products were zirconia except Captek and Caramco UltraCrown SF. These two exceptions are metal alloy. （Data from Christensen et al., 2010）

In the past few decades, the use of porcelain-fused-to-metal (PFM) restorations was considered to have predictable results. The mean veneer fracture rate is higher for zirconia restorations than for conventional PFM restorations,[13,14] but studies of direct comparison between zirconia and PFM restorations are rare.[15,16] According to Christensen, although the risk of veneer ceramic fracture is higher for zirconia restorations, the fracture rate for PFM restorations after three years of use is greater than 41% (Fig1).[15] During the processing of zirconia-based all-ceramic restorations, veneer ceramics is usually fabricated by hand-layering technique, which demands high technical expertise. In addition, the possibility of inducing porosity during layering may account for veneer fracture.

To reduce the possibility of veneer ceramic fracture, three different ways of fabricating zirconia-based all-ceramic restorations have been developed: press-on technique, CAD/CAM veneering technique, and the elimination of veneer ceramics.

1. Press-on technique

This technique is basically similar with the conventional heat-pressed technique, except for the zirconia framework. The protocol includes waxing up, forming the mold by lost-wax process, melting ceramic ingots at high temperature, and injecting the melted ceramics into the mold by pressure, followed by divesting, staining, and glazing (Fig2~7).

The press-on technique is primarily used to improve veneer ceramic fracture resistance by reducing bubble formation and multiple firing. However, according to in vitro[17,18] and in vivo experiments, the press-on technique does not result in greater fracture reduction compared with the hand-layering technique. Christensen found that the effect of the press-on technique varies with different systems.[15] Improvement in fracture resistance was not ideal in Christensen's IPS e.max ZirPress group

Fig2 Completely prepared zirconia framework on the model

Fig3 Bottom view of wax pattern and spruing

Fig4 Occlusal view of wax pattern and spruing

Fig5 After pressing, the restoration was ready for staining and glazing.

Fig6 Complete the restoration with staining and glazing

Fig7 Intraoral view of the restoration

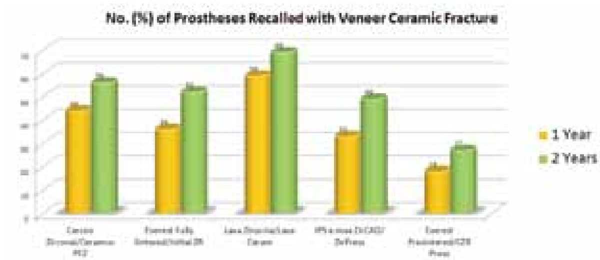

Fig8 Veneer ceramic fracture rate of 3-unit bridge with hand-layering technique and pressed-on technique. All of the products were fabricated with hand-layering technique except Zirpress and CZR, which was made by Press-on technique。（data from Christensen et al., 2010）

but was significant in the Noritake CZR Press group (leucite-containing system), suggesting that the ingredients of pressed ingots possibly play a role in fracture behavior (Fig8). Choi JE also proved that leucite-containing systems, such as CZR Press and Vita PM9, exhibit better physical properties than other systems for the press-on technique.[19,20]

2. CAD/CAM veneering technique

Veneer ceramics can be fabricated by CAD/CAM technique, through which porosity and time of firing are reduced and materials with improved strength can be used. Vita Rapid Layer Technology (RLT) and IPS e.max CAD-on technique are usually employed for bridge fabrication. In RLT, veneer ceramics is fabricated with feldspathic TriLuxe forte (flexural strength of about 150 MPa). The veneer ceramics is sintered then attached to the sintered zirconia framework by resin cement. Meanwhile, e.max CAD (flexural strength of about 360 MPa) made primarily with lithium disilicate is used in the CAD-on technique. After milling, the veneer porcelain is not sintered immediately. A special fusing glass ceramics is added between the two layers; the two layers are joined together after fusion firing (Figures 9–11).

According to Schmitter, higher fracture resistance is achieved with the CAD-on technique than with the hand-layering technique.[21] In another study comparing restorations made with the RLT and CAD-on techniques, CAD-on products revealed higher strength than RLT products with the same thickness (3534$\pm$602 N versus 1833$\pm$460 N).[22] Because of the high strength of ceramics reinforced by lithium disilicate, manufacturers suggest a minimum veneer ceramic thickness of 0.7 mm for CAD-on and 1 mm for RLT.

The two techniques described above have been developed in recent years, so relevant scientific information is scarce. We found only one short-term follow up report on the CAD-on technique. In Watzke's clinical report on the CAD-on technique,[20] single crowns and 5 three-unit bridges were included.[23] There was no veneer fracture observed after one year of use. Beuer also favored this technique over the hand-layering method.[24]

3. Eliminating veneer ceramics

What causes veneer ceramic fracture is still under debate, so another way to prevent it is to avoid completely the use of veneer ceramics. Without veneer ceramics, there can be no veneer fracture. Initially, veneer ceramics was used to improve the esthetic properties of zirconia, particularly its poor translucency. Following the development of dental material science, the translucency of zirconia has been improved. By internal and external stain techniques, full-contour zirconia restorations can now be used. However, the clinical indication of full zirconia restorations is limited to posterior regions with little esthetic demand (Fig12–16), and excess wear of the opposing teeth has become a concern because of the high strength and hardness of zirconia. Nevertheless, with proper polishing protocol, opposing enamel attrition can be avoided.[25, 26] In case of opposing teeth with intact enamel, full zirconia restorations can be used without concerns for excessive wear. Additionally, in cases where proper polishing cannot be achieved, full zirconia restorations can still be used in regions opposite that of teeth with restorations.

With the widespread use of zirconia ceramics in the dental field, veneer ceramic fracture has become a major concern. Many reasons have been identified, and among them

Fig9 Veneer ceramic with CAD/CAM technique and zirconia framework

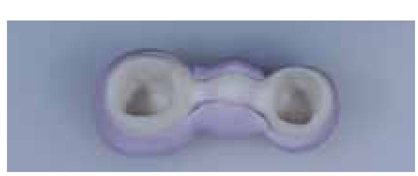

Fig10 Zirconia framework and veneer ceramic before fusion process

Fig11 After fusing and staining/glazing

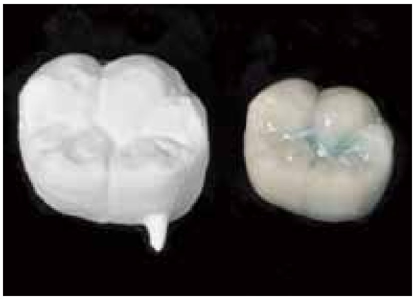

Fig12 Wax pattern and milled zirconia (before strengthening)

Fig13 Shading zirconia with colouring agent before strengthening

Fig14 After strengthening

Fig15 After staining and glazing

Fig16 Intraoral view of the restoration

is the use of the hand-layering technique. The press-on and CAD/CAM veneering techniques were both developed to reduce fracture rates. Single crowns made with the CAD-on or press-on technique exhibit higher fracture strength than those made with the hand-layering technique.[24] The simple processing procedure is another advantage. However, in cases of multiple units of fixed prosthesis made with the CAD-on technique, the frameworks must be designed with care. In addition, to prevent problems with veneer cap placement due to undercut, the use of the conventional framework design with anatomic morphology should be avoided. The modified framework design of the CAD-on technique must therefore be evaluated further. Given new zirconia with high translucency, the use of full-contour zirconia restorations has become another way to avoid veneer ceramic fracture. All of these techniques require further examination after long-term use.

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