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https://doi.org/10.15017/1931835

出版情報：九州大学, 2017, 博士（歯学）, 課程博士
バージョン：
権利関係：

J-STAGE Advance Publication: ●●●●●● ●●, 2017
Journal of Oral Science

Original

Retrospective clinical evaluation of posterior monolithic zirconia restorations after 1 to 3.5 years of clinical service

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(Received May 1, 2017; Accepted June 21, 2017)

Abstract: This retrospective study analyzed clinical outcomes of monolithic zirconia restorations (MZRs) and factors related to restoration success. Patient records were searched to identify those provided MZRs (Cercon ht) for premolars or molars between April 2012 and March 2016. All MZRs were placed according to a standardized protocol. Kaplan-Meier analysis was used to assess MZR performance and failure after recall appointments at 1 year or later. In total, 101 patients received 148 MZRs. Mean duration of follow-up was 25.0 ± 9.9 months. Six MZRs required replacement: three because of pulpal complications, one because of root fracture of an abutment tooth, one because of restoration fracture, and one because the tooth was used as an abutment tooth for a fixed partial denture after root fracture of an adjacent tooth. The cumulative MZR survival (success) rate at 3.5 years was 91.5% (95% confidence interval, 82.1% to 100%). The findings of this short-term retrospective study indicate that posterior MZRs are a therapeutic option for certain patients. In addition, several clinical procedures contribute to MZR success, including preparation design and occlusal and adhesive surface treatments.

Keywords: monolithic zirconia restoration; preparation design; surface treatment.

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Color figures can be viewed in the online issue at J-STAGE.
doi.org/10.2334/josnusd.17-0176
DN/JST.JSTAGE/josnusd/17-0176

Introduction

Ceramic restorations, especially traditional metal-ceramic restorations, have been widely used for many years (1-3). Patient demands for superior aesthetic and metal-free tooth-colored restorations have spurred development of ceramic restorations, which benefit from technologies such as computer-assisted design/computer-assisted manufacturing (CAD/CAM). The outcomes for these restorations have been good (1-5). Previous studies of the mechanical and optical properties of current ceramic materials (6-8) indicate that no ceramic system is ideal for all clinical situations. However, development and improvement of ceramic materials is ongoing and exhaustive. Because of its superior mechanical properties, zirconium dioxide (ZrO_2, known as zirconia) was introduced to dentistry and has attracted considerable attention as a framework material (3,9). Previous studies reported that zirconia restorations elicit favorable soft tissue responses (9). Although zirconia frameworks that are veneered with translucent feldspathic or glass ceramic materials for aesthetic reasons have been successful, their most common shortcoming is cohesive failure of the veneering porcelain, especially chipping (1,3,10). Strategies to prevent this limitation, including improvements in framework design and sintering, have been evaluated (11-13), but previous studies reported higher rates of veneer chipping in zirconia-based restorations than in metal-ceramic restorations, as the reasons for chipping are multifactorial (9,14,15).

Monolithic zirconia restorations (MZRs) without veneering were recently introduced to avoid chipping (16). The single-layer design and favorable mechanical properties of such restorations require less tooth preparation, which improves pulpal response in vital teeth. However, several concerns remain regarding preparation design, wear resistance and antagonist wear, bonding effectiveness, and the inherent opaque color of the material. Recent *in vitro* studies of the basic properties and clinical performance of zirconia restorations yielded promising findings (17-28). Although several clinical reports have highlighted the effectiveness of MZRs, including single restorations and fixed partial dentures for teeth and implants (29-31), few studies have investigated the outcomes of MZRs. This study retrospectively assessed MZR outcomes and describes MZR treatment modalities in light of the present findings.

Materials and Methods

This study was conducted at a private dental practice in Fukuoka, Japan, after receiving ethics approval for the study protocol from Kyushu University (#28-240). The inclusion criteria for the present study were age older than 20 years, MZR of a molar(s) or premolar(s) between April 2012 and March 2016, and at least one post-MZR follow-up visit by September 2016. Exclusion criteria included presence of probable bruxism and severe periodontal disease. Before prosthetic treatment, all patients received full-mouth periodontal examination and therapy, endodontic treatment, and caries treatment. Some patients underwent occlusal adjustment. For natural teeth, the preparation design was based on zirconia restorations suggested by the manufacturer, i.e., a chamfer margin with an occlusal reduction of 0.5 mm and an axial reduction of at least 0.5 mm. After conventional silicone impressions and preparation of stone models, wax patterns of the restorations were scanned by CAD (3 Shape Dental System, Dentsply Sirona K.K., Tokyo, Japan), and MZRs (Cercon ht, Dentsply Sirona K.K.) were machined from zirconia blanks with a CAM (Cercon brain, Dentsply Sirona K.K.) milling procedure. After the milling procedure, the restorations were sintered at 1,500°C for 8.5 h in a high-temperature sinter furnace until reaching 1,540°C for 12 h. The sintered restorations were glazed at 875°C for 15 min.

When the restorations were ready for delivery, the provisional restorations were removed for the intraoral try-ins, and fit and occlusion were checked and adjusted if necessary. Final extraoral polishing procedures were performed with solid polish (Zircon Bite, Dental Ventures of America Inc., Corona, CA, USA). MZRs for natural teeth were treated with 10-methacryloyloxydecyl dihydrogen phosphate (MDP) primers (Clearfil Ceramic Primer, Kuraray Noritake Dental Inc., Tokyo, Japan) after low-pressure alumina-blasting (0.6 MPa, sandblaster: Jet Blaster II, BSA Nagoya, Japan, alumina: Hi Aluminas, Shofu, Kyoto, Japan) and were luted with a self-etch, dual-cure, composite cement system (Clearfil Esthetic Cement, Kuraray Noritake Dental Inc., Tokyo, Japan).

Clinical follow-up assessment and data collection were done by the same clinician (H.G.). Demographics (age, sex), prosthetic treatment records, and outcomes of the patients with MZRs were ascertained during chart review. Clinical data included time in function and complications. MZR longevity was evaluated from the date the MZR was finally restored to the date of a complication or, if no complications occurred, the date of a follow-up examination at 1 year or later. A successful MZR was defined as one without complications. An MZR that was in situ and used at the follow-up visit, regardless of re-cementation or minor fracture, was defined as a surviving MZR. Data on successful and surviving MZRs were analyzed with the Kaplan-Meier method.

Results

A total of 101 patients (30 men, 71 women; mean age 45.1 ± 10.1 years; 148 MZRs) satisfied the inclusion criteria. Mean duration of follow-up was 25.0 ± 9.9 months. The distribution of zirconia restorations is presented in Table 1. No restorations were recemented or remained broken or damaged. Thus, no restorations were classified as surviving restorations, and only success rate was calculated. Overall, six MZRs for natural teeth were lost: one because of hyperesthesia, one because of root fracture of an abutment tooth, one because of restoration fracture (Fig. 1A, B), and two because of pulpitis. In addition, one restoration was removed because the tooth was used as an abutment tooth for a fixed partial denture after root fracture of an adjacent tooth. No restorations were lost for implants. The detailed characteristics of the MZRs are shown in Table 2. Kaplan-Meier curves are shown in Fig. 2. The cumulative survival, or success, rate was 91.5% (95% confidence interval, 82.1% to 100%) at 3.5 years.

Discussion

Previous reviews (3) reported estimated survival rates for ceramic restorations of 93.3% and about 95% at 5 years. The authors concluded that the survival rates for

Table 1 Distribution of monolithic zirconia restorations in dentition

Number of teeth	4	12	6	5	6	9	20	9
Tooth number	17	16	15	14	24	25	26	27
	47	46	45	44	34	35	36	37
Number of teeth	9	17	9	6	6	6	16	8

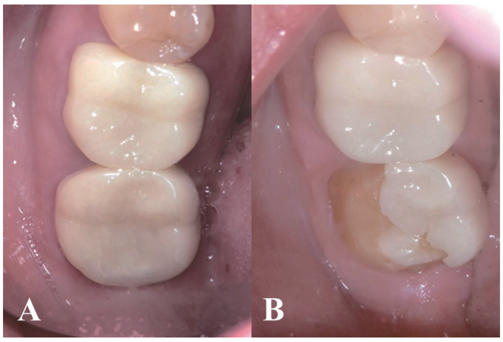

Fig. 1 Fractured monolithic zirconia restoration (MZR). A, MZR at delivery. B, Fractured MZR, 38 months after delivery.

Table 2 Complications by type, timing, and location

Complication	Number of cases	Period (months)	Tooth number
Severe hyperesthesia	1	1	14
Root fracture	1	5	36
Restoration fracture	1	38	37
Pulpitis	2	1 and 1	35 and 36
Abutment tooth for fixed partial denture	1	23	35

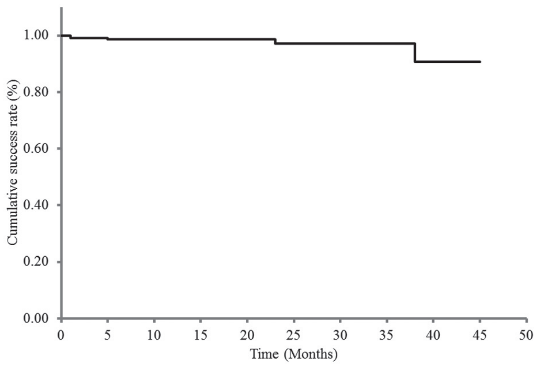

Fig. 2 Kaplan-Meier curve showing the cumulative survival rate. The cumulative survival, or success, rate was 91.5% (95% confidence interval, 82.1% to 100%) at 3.5 years.

most types of ceramic restorations were similar to those reported for metal-ceramic restorations, both in both the anterior and posterior regions. However, they suggested that zirconia-based restorations should not be considered as a primary option because of the high incidence of technical problems. Introduction of MZRs has been regarded as a clinical option to address these problems, and data from many studies indicate that MZRs are successful. However, information on the clinical performance of MZRs is insufficient. We evaluated outcomes of MZRs for posterior teeth in this study, although we recognize that the analysis is limited by the retrospective design and short duration of follow-up.

Although the duration of observation was short, the success rate, i.e., cumulative survival, was 91.5% at 3.5 years. While present and past findings cannot be directly compared, the success rate of MZRs in premolars and molars was similar to those reported previously (32,33). Before clinical evaluation of MZRs and data analysis, restoration-associated complications must be described (34). These complications have been classified as biological and technical (1,3). Loss of abutment tooth vitality, abutment tooth fracture, and secondary caries were the most frequently reported biological complications. Framework fracture, ceramic fracture, ceramic chipping, marginal discoloration, loss of retention, and poor aesthetics were the technical problems reported. A previous study reported that the three most common complications were need for endodontic treatment, porcelain veneer fracture, and loss of retention (34). The present study showed that four MZRs developed biological complications; the technical complication of restoration fracture was observed in only one MZR. Loss of retention was not observed in this study. Our treatment process and these results might be helpful in understanding several key factors regarding MZR success.

Preparation design for natural teeth

Previous studies showed that preparation design was significantly associated with MZR fracture strength (19,22,23,25,26). According to manufacturers' instructions, MZRs can be applied at a minimum thickness of 0.5 mm. However, most previous studies evaluated the strength of MZRs with a thickness greater than 0.5 mm (19,22,25). Previous findings suggest that MZRs with a thickness greater than 1.0 mm had high fracture resistance (19). In our clinical experience it is sometimes difficult to provide anatomical tooth morphology when MZR thickness is less than 1.0 mm. Stober et al. used preparations that were 0.5-0.7 mm circular and 1.0-1.2 mm occlusal (31). In the present study most teeth had an MZR thickness greater than 1.0 mm, and only one MZR fractured, after 38 months of function. However, previous studies reported that zirconia was less translucent than glass ceramic and that thicker MZRs impaired translucency and polymerization of resin cements, which resulted in poor aesthetic outcomes, decreased bonding, microleakage, and postoperative sensitivity (17,35,36).

A previous study showed that light irradiance and total irradiant energy varied by brand and thickness and that the minimum amount of light irradiance for the polymerization of resin cements can be used at thicknesses less than 1.65 mm (24). One MZR was lost because of hyperesthesia, and two were lost because of pulpitis, despite the absence of complications during provisional restorations. We suspect that poor curing of resin cement caused these failures, although the present resin cement is also a dual-cure composite cement system. An advantage of MZRs—the decreased need for tooth preparation—might not be applicable in these cases. These failures should be classified as combined biological/technical complications. Although more-detailed clinical guidelines and further studies of MZR preparation are needed, past and present evidence indicates that preparations should be designed with a thickness of 1.0-1.5 mm.

Occlusal surface manipulation

Chairside adjustment of MZRs is generally required for optimal occlusal contact. Previous studies suggest that well-polished surfaces are critical for minimizing wear (17,20,27). A previous clinical study of wear behavior reported that MZR use might be justified because MZRs exhibit less wear than other dental ceramics, although, as compared with natural teeth, monolithic zirconia results in significantly greater wear of natural antagonists (31). In the present study, all MZRs were polished after occlusal adjustments, as recommended in previous studies, and no patients reported occlusal discomfort or tooth wear. Thus, our treatment process appears to be clinically satisfactory.

MZR bonding essentials

Loss of retention is significantly greater for zirconia-based restorations than for other ceramic restorations (3). The methods necessary for creating strong adhesion to a zirconia surface are a matter of controversy. However, some previous studies reported that MZR retention depends on mechanical roughening of the inner surface and chemical treatments with adhesive monomer in primers for zirconia (21,28). Primers or adhesives containing MDP after low-pressure sandblasting are an excellent option for bonding to zirconia (37-39). These previous studies indicate that the combination of low-pressure Al_2O_3-sandblasting avoids surface damage and zirconia-specific transformation and that MDP-containing primers optimize adhesive performance. Although other alternative bonding methods have been introduced, such as tribochemical silica coating followed by silanization (21,28), our results show that the present bonding procedure was clinically satisfactory, because no MZR came off or required recementing. However, previous studies focused on the correlation between bond strength and low-temperature degradation, which might be associated with long-term bonding (21,28). This association should be investigated in future clinical studies.

In conclusion, although our findings require confirmation in longer-term studies, MZRs seem to be a suitable treatment option in posterior regions.

Conflict of interest

None declared.

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