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Fracture rate of monolithic zirconia restorations up to 5 years: A dental laboratory survey

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ABSTRACT

Statement of problem. The demand for ceramic restorations has increased over the past years because of their esthetic properties and the high cost of noble metals. However, the lack of long-term clinical studies and the difficulty of interpreting in vitro studies have placed the durability of ceramic restorations in doubt.

Purpose. The purpose of this study was to determine the failure rate of monolithic zirconia restorations due to fracture up to 5 years of clinical performance.

Material and methods. Data were collected over 5 years from 2 commercial dental laboratories. Restorations that were returned to the laboratory for remake because of catastrophic failure (fracture) were identified and included. Restorations were categorized as anterior or posterior. Each category was further divided into complete-coverage single crowns (SCs) and multiple-unit fixed dental prostheses (FDPs). Fracture rates were compared and analyzed using a chi-square test (α=.05).

Results. A total of 39 827 restoration records were reviewed and included 3731 anterior restorations (1952 SC; 1799 FDP) and 36 096 posterior restorations (29 808 SC; 6288 FDP). The overall fracture rate of up to 5 years for all restorations (anterior and posterior) was 1.09%. Fracture rates were 2.06% for all anterior restorations and 0.99% for all posterior restorations. Fracture rates were 0.97% for anterior SCs and 0.69% for posterior SCs, and the combined fracture rate (anterior and posterior) was 0.71%. For FDPs, 3.26% restorations fractured anteriorly and 2.42% fractured posteriorly, and the combined fracture rate (anterior and posterior) was 2.60%.

Conclusion. Within the relative short-term evaluation of 5 years, restorations fabricated from monolithic zirconia material displayed relatively low fracture rates. Anterior restorations fractured at a slightly higher rate than posterior restorations, and FDPs fractured at a rate double that of SCs. (J Prosthet Dent 2016;■:■-■)

Clinically based evidence is a key factor in distinguishing survival and longevity of one material versus those of another. Metal and metal-based restorations are recognized as predictable, long-term indirect restorative materials.[1] Leempoel et al[2] reported that 95% of metal ceramic restorations were intact and functional at 11 years. However, the cost of noble metal alloys has increased considerably over the past years. In addition the esthetics, biocompatibility, wear resistance, low thermal conductivity, and color stability[3] of metal-free ceramic indirect restorations have led to increased demand. Ceramic restorations are frequently placed in contemporary practice.

Clinically based evidence regarding the success and longevity of most ceramic systems is not available when these systems are introduced to the market. Despite possessing impressive mechanical, physical, and optical properties in vitro,[4] clinical longevity cannot be accurately predicted by relying solely on these tests.[5] Criteria developed in a study by Schärer[6] should be considered the golden rule to be adopted when the success of any given ceramic system is evaluated. Schärer suggested that data from independent clinical trials should be provided indicating a 95% success rate of a ceramic system at

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Clinical Implications

In the relatively short term of 5 years, monolithic zirconia restorations displayed low fracture rates.

5 years.[6] Schärer's criteria[6] are somewhat difficult to use however because independent clinical data are rarely available at 5 years. Clinical trials are time consuming and expensive, and although manufacturers frequently support clinical trials, data from such trials are not available until 8 to 10 years after the product has been introduced commercially.

One of the relatively new ceramic materials for fixed dental prostheses is monolithic zirconia (also known as anatomic-contour zirconia). The predecessor of monolithic zirconia was layered zirconia using a high-strength zirconia as the core and a feldspathic ceramic veneer. Studies of layered zirconia have reported that chipping of the veneering porcelain is problematic.[7-9] However, these same studies demonstrated very low failure rates of the underlying zirconia core. Monolithic zirconia crowns lack veneering porcelain and thus resist chipping. Monolithic zirconia is widely used in clinical practice for single- and multiple-unit restorations, abutments, complete-arch implant–supported prostheses, and orthodontic brackets.[10] Classified as a semitranslucent restorative material,[11] monolithic zirconia possesses acceptable esthetic properties after polishing, staining, and glazing. The material is wear-friendly to the enamel antagonist in its polished state[4] and can be cemented to an adequately prepared tooth structure with nonadhesive cement or bonded by combining mechanical and chemical pretreatments with a resin-based luting agent.[12] In addition to its desirable physical properties,[13] chemical stability, and low thermal conductivity,[14] one of the most desirable characteristics of monolithic zirconia is its relatively low cost.

This study was designed to report data regarding the early survival rates of monolithic zirconia restorations used to restore a single crown (SC) or as a multiple-unit fixed dental prosthesis (FDP) for anterior and posterior teeth. To the best of the authors' knowledge, limited clinical data are available for monolithic zirconia restorations. Thus, information regarding the early clinical performance of monolithic zirconia restorations was collected from 2 major dental laboratories with database systems, which permitted the collection of such data. Only restorations returned to the laboratory for remaking because of fracture were considered failures and included in survival calculations. It was assumed that the clinician would return the fractured restoration to the laboratory, requiring a remake of the restoration as both dental laboratories provide a 5-year warranty service on monolithic zirconia restorations at no additional cost.

Table 1. Total number of monolithic zirconia restorations according to their location, placed over 5 years

Location	Restorations Placed	Restorations Fractured	Fracture Rate (%)
Anterior restorations	3731	77	2.06
Posterior restorations	36 096	357	0.99
Total	39 827	770	1.09

MATERIAL AND METHODS

Two major dental laboratories in the United States that provided a 5-year warranty service and a no-cost remake of monolithic zirconia restorations that failed because of catastrophic restoration failure (fracture) were approached for this study. All restorations included in the selection criteria were cemented onto the natural dentition, and no implant-supported restorations were included. Brands of zirconia material used in the 2 laboratories were Bruxzir (Glidewell Laboratories), Katana (Kuraray Noritake Dental Inc), Zirlux (Henry Schein), and Zenostar (Ivoclar Vivadent Inc). Data were collected from the laboratories' database systems, which tracked the number of restorations returned to the laboratory for complete remaking of the restoration because of fracture. The data included in this study were continuously collected for a period of 5 years. All monolithic zirconia restorations fabricated by the 2 dental laboratories between June 2010 and June 2015 were included. Types of restorations and failures were recorded on a printed assessment sheet. Monolithic zirconia restorations were categorized as anterior and posterior restorations. Each category was further divided into complete coverage SC and FDP. Remakes or minor adjustments because of poor marginal fit, shade match, or anatomic contour were excluded from the study. Fracture rates of monolithic zirconia restorations according to the location of the restoration, type of restoration, and annual fractures were compared and analyzed with chi-square tests (α=.05).

RESULTS

A total of 39 827 restorations were evaluated in this study, of which 3731 were anterior restorations (1952 SCs; 1799 FDPs) and 36 096 were posterior restorations (29 808 SCs; 6288 FDPs). Thus, approximately 10 times as many posterior restorations were evaluated as anterior restorations, and approximately 4 times as many SCs were evaluated as FDPs.

Over the reported period of 5 years, 2.06% of all anterior monolithic zirconia restorations failed because of catastrophic fracture of the restoration, whereas only 0.99% of all posterior monolithic zirconia restorations

Table 2. Fracture rates of monolithic zirconia restorations according to type of restoration placed over 5 years

	Anterior			Posterior			
Type of Restoration	Restorations Placed	Restorations Fractured	Fracture Rate (%)	Restorations Placed	Restorations Fractured	Fracture Rate (%)	Total Fracture Rate (%)
Single crowns	1952	19	0.97	29 808	205	0.69	0.71
Multiple-unit fixed dental prosthesis	1779	58	3.26*	6288	152	2.42*	2.60*

*Statistical differences between types of restoration: $P<.001$.

fractured. The overall fracture rate of all monolithic zirconia restorations, regardless of their position or type of restoration, was 1.09%. Data for total number of restorations placed and their respective fracture rates are reported in Table 1.

Fracture rates for anterior SCs were 0.97% and 0.69% for posterior SCs. The FDPs fractured at a rate of 3.26% anteriorly and 2.42% posteriorly. The combined fracture rate for SCs (anterior and posterior) was 0.71%, and the combined fracture rate for FDPs (anterior and posterior) was 2.60%. FDPs fractured at a significantly higher rate than SCs, regardless of position ($P<.001$) (Table 2). No statistically significant differences were found in annual fracture rates of monolithic zirconia restorations over the 5-year period ($P>.05$).

DISCUSSION

This study clearly does not deny the need for properly designed clinical trials but rather provides data that might help clinicians avoid a ceramic material that lacks definitive clinical evidence for success. The information presented identified the number of early or premature failures that may occur with the monolithic zirconia ceramic system.

The monolithic zirconia restorations evaluated in this study did not show a high rate of catastrophic failure at 5 years. Another popular ceramic system, a lithium disilicate (IPS e.max; Ivoclar Vivadent Inc), has also demonstrated low short-term fracture rates, particularly in the monolithic form.[15]

One notable advantage of adopting the methodology in this study was the ability to obtain data from a large sample size (39 827 restorations), which could be analyzed quickly. This approach also used a clinician-based concept in contrast to reports from clinical trials using specialists, which may require 8 to 10 years to extract useful information. However, some failed restorations might not have been accounted for because the patient might not have returned to the dentist who originally placed the restoration. Another possibility is that the clinician might have chosen to replace with another type of restorative material or send the replacement restoration to another dental laboratory; however, this was probably a rare occurrence, given the laboratories' 5-year warranty. To the knowledge of the authors, no published controlled, clinically based trials reporting the success rate of monolithic zirconia SCs or FDPs over a significant period of time are available.

All restorations included in the selection criteria were supported by natural dentition, and no implant-supported restorations were included. Data clearly indicate that most monolithic zirconia restorations are placed in the posterior region, which demonstrated approximately half of the fracture rate of monolithic zirconia restorations placed in the anterior region. However, restorations in both regions exhibited fracture rates well below the 5% criteria suggested by Schärer[6] as acceptable up to 5 years of clinical service. Also, data indicated that SCs were placed approximately 4 times more often than FDPs, with FDPs fracturing at a rate more than double that of SCs.

The cause of reported fracture cannot be deduced from this study. Furthermore, it is not possible to impart the sole cause of failure to the material properties of monolithic zirconia. Other factors related to the fabrication process and clinical tooth preparation might have played major roles. Brands of monolithic zirconia material used between the 2 laboratories were Bruxzir (Glidewell Laboratories), Katana (Kuraray Noritake Dental Inc), Zirlux (Henry Schein), and Zenostar (Ivoclar Vivadent Inc), and no generic brands of zirconia were considered. Personal communication with master technicians in the visited laboratories revealed that the most fractures occurred on the day of crown delivery. The idea of a conservative preparation required for monolithic zirconia restorations may have been misinterpreted. Many dentists appear to use minimal reduction (less than 0.6 mm) with featheredge margins. This violates the minimum thickness (0.6 to 0.8 mm) recommended by manufacturers for monolithic zirconia restorations. This renders the zirconia material in those very thin areas vulnerable to chipping and fracture during restoration delivery. Parameters required for tooth preparation must be followed as these requirements are rarely met.[16] In vitro studies analyzing failure methods of ceramic restorations have been proposed.[17] However, clinical studies examining the failure modes of ceramic restorations to better predict their success and longevity are lacking.[18]

CONCLUSIONS

Based on the findings from this survey of 2 major dental laboratories, the fracture rate for posterior SCs was 0.69% and 0.97% for anterior SCs and 0.71% for combined fracture rate. That failure rate is well below the accepted failure rate (5% at 5 years) suggested by Schärer.[6] Fracture rates of FDPs are higher than those of SCs, and the fracture rates of FDPs in the posterior region are fewer than those in the anterior region. Indirect restorations fabricated from monolithic zirconia material exhibit a fairly low fracture rate up to 5 years.

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