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CLINICAL RESEARCH

Survival of 2039 complete arch fixed implant-supported zirconia prostheses: A retrospective study

Avinash S. Bidra, BDS, MS,[a] Michael Tischler, DDS,[b] and Claudia Patch, DMD[c]

ABSTRACT

Statement of problem. Presently, data for the survival of 1-piece complete arch fixed implant-supported zirconia prostheses are limited.

Purpose. The purpose of this retrospective study was to evaluate the survival outcomes of 1-piece complete arch fixed implant-supported zirconia prostheses fabricated by a single dental laboratory supporting several clinicians.

Material and methods. Outcome data were collected over a 5-year period from a large commercial dental laboratory that fabricated 2039 1-piece complete arch fixed implant-supported monolithic zirconia prostheses. All prostheses were fabricated using the same zirconia system from 1 manufacturer, using standardized protocols. The zirconia prostheses were predominantly monolithic, with veneered porcelain restricted to the gingival region. Because a 5-year warranty against fracture was offered by this dental laboratory, prostheses that were returned to the laboratory for remake because of catastrophic failure (fracture) or technical complications were identified, and data were analyzed using a life table.

Results. Of the 2039 zirconia prostheses evaluated, at least 319 prostheses had a minimum of 3 years of clinical service, and 69 prostheses had a minimum of 4 years of clinical service. A total of 6 fractures were reported, resulting in a first-year interval survival rate of 99.8% and a 5-year cumulative survival rate of 99.3%. Six zirconia prostheses were returned to the laboratory during the 5-year period because of technical complications related to the debonding of titanium cylinders, and 3 prostheses were returned because of fracture of the titanium cylinders. No prostheses were returned because of chipping of the veneered gingival porcelain.

Conclusions. Practice-based evidence from this large sample, short-term retrospective study showed that 1-piece complete arch fixed implant-supported zirconia prostheses with veneered porcelain restricted to the gingival region showed a cumulative survival rate of 99.3% in a 5-year period. The technical complication rate related to this type of prosthesis was minimal. (J Prosthet Dent 2017;■:■-■)

Complete arch fixed implant-supported prostheses (CAFIPs) (also called fixed complete dentures) have been demonstrated to be a highly successful treatment for patients with edentulism.[1-9] Conventionally, CAFIPs were fabricated with a metal framework and acrylic resin for artificial teeth and gingiva. This design remains a popular choice because of its long history of good clinical performance, low fabrication cost, easier reparability, and clinician's comfort level with this material.[2,5,7] Multiple clinical studies and systematic reviews have reported the high rate of fracture and wear of the acrylic resin and the need for repair, replacement, and lifelong maintenance.[1-9] This maintenance represents a significant inconvenience, financial cost, and loss of treatment satisfaction for both patient and clinician. Moreover, patients with distal cantilevers, limited prosthetic space, or parafunctional habits have even higher complication rates.[5,6] Conventional alternatives to metal-acrylic resin fixed complete dentures are metal-composite resin or metal-ceramic, both of which are expensive, time-consuming to fabricate, difficult to repair, and technique sensitive, precluding their use for many patients.[10]

Zirconia has emerged as an alternative prosthetic material for CAFIPs and is purported to solve many of the problems related to metal-resin and metal-ceramic prostheses.[11-20] Two recent systematic reviews have summarized the status of this material as a promising

M.T. is the owner of Tischler Dental Laboratory; all authors have used Tischler Dental Laboratory extensively for treatment of their patients in private practice.
[a]University of Connecticut and Private Practice, Meriden, Conn.
[b]Private Practice, Woodstock, NY.
[c]Private Practice, Woodstock, NY.

Clinical Implication

Because of the excellent short-term survival outcomes and low rate of technical complications, the 1-piece complete arch fixed implant-supported zirconia prosthesis with veneered porcelain restricted to the gingival region is an acceptable choice in the fixed implant rehabilitation of the edentulous patient.

alternative. Abdulmajeed et al[21] reported that clinical studies are lacking on the long-term outcome of zirconia CAFIPs and concluded that the use of monolithic zirconia is still associated with high short-term success. Bidra et al[22] analyzed 12 clinical studies and reported a significantly low failure rate of 1.4% from zirconia framework fractures in the short term but also reported that zirconia CAFIPs have a substantial rate of minor complications related to the chipping of veneered porcelain (14.7%). The use of monolithic zirconia with only gingival characterization or zirconia that is veneered only at the gingiva was recommended.

The use of completely monolithic zirconia or minimally veneered zirconia with feldspathic porcelain restricted to the gingival region in CAFIPs has multiple empirical advantages for the clinician and patient, including reduced laboratory cost because of the automation involved in fabrication; good dental and gingival esthetics; superior strength, durability and wear characteristics; superior fit of the prosthesis due to digital fabrication; availability of a permanent digital file for future reproduction; opportunity for digital fabrication of a prototype/replica prosthesis in acrylic resin for patient approval and adjustments; superior biocompatibility compared with metal alloys; and reduced plaque accumulation and favorable soft tissue response.[22] However, the disadvantages related to the use of this material include the inability to repair framework fractures; difficulty in adjusting and polishing[14,22]; low tolerance of minor inaccuracies in the impression, resulting in fractures during insertion; and minimal long-term scientific data for clinical outcomes.

Denry and Kelly[23] discussed monolithic zirconia, including the long-term chemical stability and tribological behavior of the material. They recommended that every step of the fabrication process, including blank fabrication, green machining, sintering process, and surface treatments (chemical, thermal, or mechanical) must be carefully controlled to achieve the expected mechanical and chemical properties.[23] Prudent manufacturers who ensure that these processes are carefully controlled have recently started to provide warranties ranging from 5 and 7 years on their zirconia restorations, including CAFIPs, which is significantly reassuring to clinicians and patients.

Therefore, the purpose of this retrospective study was to evaluate the survival outcomes of 1-piece complete arch fixed implant-supported zirconia prostheses fabricated by a large commercial dental laboratory.

MATERIAL AND METHODS

Outcome data from a large dental laboratory in the United States that provided a 5-year warranty and a no-cost remake of a predominantly monolithic zirconia CAFIP were analyzed. All prostheses were fabricated by this laboratory, using the same kind of zirconia (Prettau Zirconia; ZirkonZahn) from 1 manufacturer (ZirkonZahn), using standardized fabrication protocols recommended by the manufacturer. All zirconia prostheses were screw-retained, predominantly monolithic, and with veneered porcelain restricted to the gingival region. The authors collected data for all zirconia prostheses from the dental laboratory's database system from January 1, 2012, to December 31, 2016 and recorded the number of prostheses returned to the laboratory by the clinician for remake or adjustments to the prosthesis.

In this study, the authors defined failure as fracture of any part of the zirconia prosthesis that required remake of the prosthesis by the dental laboratory. Survival was defined as zirconia prostheses that were not returned to the dental laboratory after insertion by the clinician. Prosthetic complication was defined as an unanticipated event that affected any or all of the zirconia prosthesis and required a material-specific laboratory intervention but without replacement and remake of a new zirconia prosthesis. The zirconia prosthesis itself had to be intact and in one piece. Examples of unanticipated prosthetic complications included chipping of the veneered gingival porcelain, debonding of the titanium cylinder, or fracture of the titanium cylinder. Remakes or laboratory interventions because of shade mismatch, occlusal discrepancy, or patient dissatisfaction for any reason were all excluded from this study as they were considered clinician-driven factors that could have confounded the results of the study.

RESULTS

Data related to a total of 2039 zirconia prostheses were analyzed in this study over the 5-year evaluation period (Table 1). These prostheses were fabricated for hundreds of clinicians, using a variety of commercially available implant systems and included axially aligned as well as tilted implants. Additionally, the zirconia prostheses were fabricated for implant-level and abutment-level prosthetic platforms. All prostheses had an indirect zirconia interface (bonded to prefabricated or custom metal cylinders) as opposed to the first-generation design of direct zirconia interface with implants and abutments. Additionally, all zirconia prostheses were fabricated with artificial gingiva, which was added by veneering

Table 1. Descriptive data related to 2039 complete arch fixed implant-supported zirconia prostheses

Total No. of Complete Arch Fixed Implant-Supported Zirconia Prostheses Delivered To Clinicians Over 5-Year Period.	No. of Prostheses Remade Because of Reported Fractures	No. of Prostheses With Technical Complications Because of Reported Chipping of Veneered Porcelain*	No. of Prostheses With Technical Complications Caused by Debonding of Titanium Cylinder	No. of Prostheses With Technical Complications Caused by Fractured Titanium Cylinder
2039	6: 4 were maxillary prostheses, and 2 were mandibular prostheses; 2 were single-arch prostheses, and 4 were double-arch zirconia prostheses	0	6: 4 maxillary prostheses, and 2 were mandibular prostheses; 3 were single-arch prostheses, and 3 were double-arch zirconia prostheses	3: 0 maxillary prostheses and 3 were mandibular prostheses; 2 were single-arch prostheses, and 1 was a double- arch zirconia prosthesis

*Note: veneered porcelain restricted to gingival region.

gingiva-colored porcelain after a digital cut-back design. No prostheses were dentition-only replacements,[10] indicating that sufficient prosthetic space existed for all prostheses for gingival porcelain. The teeth on all 2039 zirconia prostheses were left monolithic with only coloring for characterization and did not have any cut-back for adding veneered tooth-colored porcelain. Although most zirconia prostheses (>90%) had a resin prototype prosthesis that was scanned to produce the definitive prosthesis, the exact number was not recorded.

Of the 2039 zirconia prostheses evaluated, at least 319 prostheses had a minimum of 3 years of clinical service, and 69 prostheses had a minimum of 4 years of clinical service. As far as the authors are aware, these numbers represent the largest sample size in current scientific publications.[22] Six fractures were reported, resulting in a first-year interval survival rate of 99.8% and a 5-year cumulative survival rate of 99.3% (Table 2). Life table survival analysis indicated that 3 fractures occurred during the first year interval, 2 more fractures during the second year interval, and 1 fracture during the third year interval. Although the exact cause of fracture was not determined by the dental laboratory, the reasons for fracture recorded by the laboratory were inaccurate casts submitted by the clinician (4 fractures), reduced prosthetic space (1 fracture), and adjacent implants positioned too closely (1 fracture). Details related to the 6 fractures in this study are provided in Table 3. Six prostheses (0.29%) were returned to the laboratory because of technical complications caused by debonding of the titanium cylinder, and 3 prostheses (0.14%) were returned because of fracture of the titanium cylinder. No prostheses (0%) were returned because of chipping of the veneered gingival porcelain. All technical complications were successfully addressed by the laboratory and returned to the clinician without any subsequent returns.

Table 2. Five-year life table survival analysis of all complete arch fixed implant-supported zirconia prostheses

Time Interval in Years	No. of Zirconia Prostheses in Interval	No. of Failures in Interval	Interval Survival Rate (%)	Cumulative Survival Rate (%)
0-1	2039	3	99.85	99.85
1-2	1062	2	99.65	99.50
2-3	671	1	99.78	99.29
3-4	319	0	100.0	99.29
4-5	69	0	100.0	99.29

DISCUSSION

The purpose of this retrospective dental laboratory-based study was to report the survival outcomes of predominantly monolithic zirconia CAFIPs using a large sample database of 2039 prostheses. Analyzing data related to the warranty of prostheses offered by dental laboratories is not new, and recent studies of data for contemporary ceramic restorations from large commercial laboratories have provided insight into the performance of these restorations in clinical practice.[24-26] The warranty concept is based not only on the fidelity of the biomaterial but also on the reduced cost of fabrication due to modern digital technology and reduced human labor. However, manufacturer and dental laboratory clauses require that clinicians adhere to clinical procedures and protocols without any errors.

With respect to zirconia CAFIPs, the clinician's labor and time in removing a fractured prosthesis and replacing it with an interim (prototype) resin prosthesis is minimal because of the screw-retained nature of the prosthesis. Thus, the warranty assures the patient and clinician of simplicity in the indemnification of a fractured prosthesis. Additionally, a stored digital file allows easier fabrication of a new monolithic zirconia prosthesis to mimic the original prosthesis. Additionally, the patient can continue to wear the prototype prosthesis (milled from the same scan using resin-based materials) during the fabrication of a new prosthesis.[22]

Dental laboratory outcome data derived from warranty claims provide a unique advantage in prosthodontics research to the delivery of practice-based evidence (PBE). Because the prostheses are indemnified by the warranty, clinicians are most likely to report failures or complications to the dental laboratory in order to obtain a new prosthesis or modifications at no cost.[24-26] This allows the laboratory to record the failure/complication data, which can then be tracked and analyzed by future investigators to understand the clinical performance of a biomaterial and/or prosthesis in an uncontrolled clinical setting. Thus, the clinical performance of

Table 3. Descriptive characteristics of 6 failures (fractures) of complete arch fixed implant-supported zirconia prostheses observed in this study

Fractured Prosthesis	Time Interval (Years) Between Delivery To Clinician and Report of Fracture	Location of Fractured Zirconia Prosthesis	Nature of Opposing Jaw Prosthesis	Additional Prosthetic Complications Besides Fracture	Laboratory-Attributed Cause of Fracture	Resolution of Fractured Prosthesis Situation
Fractured prosthesis-1	3	Maxilla	Zirconia prosthesis in both jaws	None	Reduced vertical prosthetic space	New zirconia prosthesis made which fractured again within 1 year, after which zirconia was abandoned as restorative material.
Fractured prosthesis-2	2	Maxilla	Zirconia prosthesis in both jaws	None	Inaccurate casts that were submitted by clinician	Successful resolution by remake of zirconia prosthesis over corrected cast.
Fractured prosthesis-3	2	Maxilla	Zirconia prosthesis in single jaw	None	Inaccurate casts that were submitted by clinician	Successful resolution by remake of zirconia prosthesis over corrected cast.
Fractured prosthesis-4	1	Mandible	Zirconia prosthesis in single jaw	None	Inaccurate casts that were submitted by clinician	Successful resolution by remake of zirconia prosthesis over corrected cast.
Fractured prosthesis-5	1	Mandible	Zirconia prosthesis in both jaws	None	Inaccurate casts that were submitted by clinician	Successful resolution by remake of zirconia prosthesis over corrected cast.
Fractured prosthesis-6	1	Maxilla	Zirconia prosthesis in both jaws	None	Implants positioned too close to each other	Successful resolution by remake of zirconia prosthesis by exclusion of 1 implant.

the material is documented and measured across numerous clinicians and patients, yielding a large sample size and contributing to PBE. This directly contrasts with clinical trials, which typically occur under controlled conditions on a small, carefully selected number of participants who are treated by experienced clinicians.[27] Although high-quality clinical trials test novel materials and techniques, they are currently limited by funding and patient dropout. Practice-based evidence data from dental laboratories may fill an important gap in prosthodontic research by allowing large-scale multiclinician analysis of novel treatments.[27]

Failure data from the present retrospective study are slightly lower than the findings from a recent systematic review of complete arch zirconia prostheses, which reported a 1.4% overall fracture rate.[22] This could be attributable to the different clinical performance of different zirconia materials. Likewise, the complication rate related to the fracture of veneered porcelain in this study was 0% compared with the 14.7% rate reported by Bidra et al.[22] This is because in the present study, the veneered porcelain in all 2039 zirconia prostheses was restricted to the gingival region. The authors believe that the high survival and better outcomes reported in the present study are due to the following factors: 1) superior quality of the zirconia used; 2) careful adherence to laboratory protocols, including the slow heating and cooling of the zirconia; 3) mandating a minimum of 12-mm prosthetic space above the soft tissue level to provide sufficient strength for the zirconia and to comply with the terms of the warranty; 4) use of the implant manufacturer's titanium cylinders bonded to zirconia to provide a metal-to-metal interface over the implants or abutments; 5) provision of a milled acrylic resin prototype prosthesis in most situations (in some situations, the clinicians opted against this recommendation) to allow adjustment of occlusion and esthetics before fabricating the zirconia prosthesis; and 6) quality control at every step of fabrication, including returning questionable impressions, casts, and other treatment items to the clinician for reverification. The excellent results of this study are true only for the zirconia prostheses made by the present dental laboratory adhering to the protocols described in this article. Whether the findings would be the same if the 6 factors described here were not followed is unknown.

Like most retrospective studies, there are some limitations to this study: first, although the likelihood of prostheses with failures and complications being returned to the dental laboratory is high because of the warranty and easier retrievability, the complication rate in patients who might have died, moved, or never returned to their clinician for a follow-up is unknown; second, most of the 2039 zirconia prostheses had a follow-up period of less than 3 years, indicating that the true 5-year survival rate is presently unknown; third, the data reported in this study are only restricted to 5 years, and future studies are needed to determine the long-term survival rate; fourth, although a large number of prostheses were included in all categories, this study could not provide data for exact numbers for maxilla versus mandible, single-arch versus double-arch prostheses, distal cantilever versus noncantilever prostheses, and implant-level versus abutment-level prostheses; and fifth, the study could not provide data for patient satisfaction related to the zirconia prostheses. Nevertheless, this is a large sample study of 1-piece complete arch fixed implant-supported zirconia prostheses showing excellent clinical outcomes, and it supports the argument that predominantly monolithic zirconia is an excellent choice for fixed implant rehabilitation of the edentulous patient. Further long-term clinical studies may answer these questions.

CONCLUSIONS

Within the limitations of this large, short-term retrospective study, the following conclusions were drawn:

1. One-piece complete arch fixed implant-supported zirconia prostheses with veneered porcelain restricted to the gingival region showed a cumulative survival rate of 99.3% in a 5-year period. Of the 2039 zirconia prostheses evaluated, at least 319 prostheses had a minimum of 3 years of clinical service, and 69 prostheses had a minimum of 4 years of clinical service.
2. The complication rate of fractured veneered gingival porcelain was 0%.
3. The complication rate of debonding of titanium cylinders was 0.29%, and the fracture of titanium cylinders was 0.14%, both of which are negligible.

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Corresponding author:
Dr Avinash S. Bidra
University of Connecticut Health Center
263 Farmington Ave, L7041
Farmington, CT 06030
Email: avinashbidra@yahoo.com

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