



School of  
Dental Medicine

**Prostheses Survival Rates and Technical Complications of Monolithic Zirconia Fixed  
Complete Arch Dental Prostheses**

by

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**ABSTRACT:****OBJECTIVE:**

The primary objective of this study was to determine the prosthesis survival and complication rates associated with monolithic zirconia implant-supported fixed full dental prostheses (IFCDPs) in completely edentulous patients after a minimum of 1-year clinical follow-up.

**MATERIALS AND METHODS:**

A convenience sample of subjects that underwent treatment with zirconia IFCDPs at the Division of Postgraduate Prosthodontics at Tufts University School of Dental Medicine (TUSDM) was used in the present retrospective study, yielding a total of 20 zirconia IFCDPs (14 participants). This study was an observational single-center retrospective clinical cohort study. Descriptive statistics were calculated. SPSS v. 28 (IBM Corp., Armonk, NY, USA) was used in the analysis.

**RESULTS:**

A study of 14 participants (28.6% female and 71.4% males (mean age: 67.6 years) investigated the survival and complication rates with monolithic zirconia dental prostheses. The mean duration of prosthesis use was approximately 36.8 months. The majority of the participants (85.7%) reported not using a nightguard. Bruxism was reported by 21.4% of the participants. The distribution of opposing dentition among the participants was as follows: 28.6% had natural dentition, 21.4% had implant-supported dentition, removable

prosthesis, and combination of teeth and implants, and 7.1% had an implant overdenture. Out of the 20 arches, 60.0% of monolithic zirconia IFCDPs were made in the maxilla, and 40.0% in the mandible. Among the minor technical complications that were found, "Occlusal Wear" 'Chipping' and "Loss of Access Hole Material" emerged as the most prevalent, occurring in 25.0%,20.0%, and 20.0% of cases, respectively. In the case of the major complication "Fracture of Screw," one instance of occurrence was recorded, representing 5.0% of the cases. The mean of the number of major complications was 0.05 events. The mean number of Minor complications was slightly more common (it was 1.15 events). The mean total number of complications was 1.2 events. No prosthesis failure in this study accounted for 100% survival rate of the IFCDPs.

#### **CONCLUSION:**

The study observed 14 individuals who received 20 monolithic zirconia implant-supported fixed complete-arch dental prostheses. Remarkably, all prostheses demonstrated a 100% survival rate, indicating no failures. The research yields valuable insights into the technical complications associated with monolithic zirconia prostheses. Nonetheless, the study's scope is limited by its small participant size and short follow-up period, potentially affecting the general applicability and long-term outcomes. To strengthen the evidence for dental prosthetic treatments, it's recommended that larger and more diverse studies with extended observation periods be undertaken.

## I) Background and rationale

The continuing population growth worldwide and the increase in the proportion of older individuals are leading to a rise in the need for the treatment of edentulism. There is an increase in the number of patients who need care for complete edentulism, although the occurrence of edentulism is decreasing. The increase is due to a significant rise in the adult population aged 55 and over. <sup>1</sup>

It is widely established that the loss of all teeth in one or both dental arches results in major anatomical, functional, esthetic, and psychological alterations, lowering patients' quality of life and comfort dramatically. <sup>2</sup> Until a few years ago, the only treatment option was a removable full denture based on physical-chemical and biomechanical retention principles. However, the improvements acquired were insufficient to ensure the patients' pleasure and comfort, particularly those with a low alveolar ridge and low retentive ability. With a strong clinical and scientific foundation, implant-supported fixed prostheses are a dependable treatment modality for tooth replacement satisfaction in situations of total edentulism. <sup>3</sup>

Historically, complete-arch fixed implant-supported dental prostheses were constructed using noble alloy frameworks and acrylic resin or denture teeth for veneering. <sup>4</sup> Around 30 years ago, the mandibular screw-retained metal- resin implant fixed complete dental prosthesis (MRIFCDP) was developed by Brånemark for dental use. It was initially known as a hybrid prosthesis or fixed bone-anchored prosthesis. <sup>5 6</sup> The dental restorations involved connecting denture teeth to a metal framework using acrylic resin. They were then fixed to six implants that were positioned between the mental foramina. Presently, the same prosthetic design is utilized for four to six implants. <sup>7</sup> One of the most extensively

researched treatment methods for restoring an edentulous arch with a permanent implant prosthesis is through the use of metal-acrylic hybrids.

Because of its long history of good clinical performance, low manufacturing cost, easier reparability, and clinician comfort level with this material, this design remains a preferred option.<sup>8</sup> The use of MRIFCDPs has resulted in a better quality of life for patients in terms of oral health when compared to traditional dentures or implant-retained overdentures. A fixed prosthesis offers benefits in terms of functionality, appearance, and emotional well-being over removable prosthetics, leading to greater patient satisfaction.<sup>9</sup> A study conducted by Barootchi et al. showed that the counted survival rate of metal-acrylic prostheses after 5 years was  $83.0\% \pm 11.1\%$ . Similarly, at the 8-year mark, the calculated rate for metal-acrylic hybrids was  $51.7\% \pm 12.1\%$ , which decreased to this level by the 10-year follow-up.<sup>10</sup> During the study, it was observed that out of the metal-acrylic fixed implant prostheses, 22 of the hybrid prostheses (51%) experienced denture teeth fractures on average after nearly 10 years.<sup>10</sup> Other research conducted on IFCDPs made of metal and acrylic resin have been found to have a range of complications, with veneer fracture being the most common. After 15 years of use, nearly 70% of these prostheses showed some form of veneer fracture.<sup>11</sup> Another study by Purcell et al. found that out of 46 MRIFCDPs, there were 28 instances of denture teeth fractures within an average recall period of 7.9 years. This suggests a high frequency of such incidents.<sup>12</sup>

Several clinical investigations and systematic reviews have revealed a high rate of fracture and wear of the acrylic resin, as well as the necessity for repair, replacement, and lifelong care. This maintenance is associated with, financial cost, and loss of treatment satisfaction for both the patient and the practitioner.<sup>8</sup>

It has been reported by Mackert et al. in 2022 that the survival rates for MRIFCDPs were quite low, with only 54% at 5 years and 32% at 10 years. Common complications that have been observed with MRIFCDPs include fractures in acrylic resin, loosening or breaking of prosthetic screws, wear and fractures in denture teeth, fractures in prosthesis frameworks, and unsatisfactory gingival appearance.<sup>13</sup> English suggested in the 1990s that the cantilever length could be safely extended up to 1.5 times the anteroposterior implant spread.<sup>14</sup> However, using a prosthesis with a posterior cantilever arm can lead to the distal extension breaking when it comes into contact with natural teeth or another IFCD, which increases the risk.<sup>13 15</sup> The acrylic resin around the metal bar fracturing catastrophically was the most common reason for prosthesis replacement, followed by wear of the acrylic resin denture teeth.<sup>13</sup> According to Papaspyridakos et al.'s report, the MRIFCDPs had the highest occurrence of abutment screw loosening as a technical complication related to implants. The second most frequent complication was screw fracture, which occurred due to parafunction leading to an excessive load on the occlusal surface.<sup>16</sup> The most commonly reported technical complication for MRIFCDPs is chipping or fracturing of the veneering material, and the second most frequent technical complication related to prostheses was the loss of filling material that provided access to the screw.<sup>16</sup>

As mentioned earlier, studies have shown that hybrid prostheses often have many complications. Thanks to advances in technology, titanium and other materials can now be used for dental frameworks. Additionally, dental ceramics or composites can be used for veneering.<sup>4</sup> Metal-composite resin or metal-ceramic are conventional alternatives to metal-acrylic resin fixed complete dentures.<sup>8</sup>

In a retrospective study by Chochlidakis et al, the survival rates and technical complications of a patient cohort were evaluated for up to 5 years of follow-up.<sup>17</sup> Out of the 48 prostheses, 10 were metal-ceramic and 38 were metal acrylic resin. The most commonly reported minor complication in the metal acrylic resin group was the loss of access hole material at a rate of 5.26% per year, while the metal-ceramic group experienced minor wear of the prosthetic material at a rate of 9.37% per year. Both groups had major wear of the prosthetic material, the most frequent major complication, with rates of 5.49% and 7.45% for the metal acrylic resin and metal-ceramic groups, respectively. No significant difference was observed between the two groups in regards to measuring patient satisfaction.<sup>17</sup> After conducting a retrospective clinical study, it was concluded that after being observed for 3.5 years, the IFCDPs showed a high cumulative survival rate of 88%. Additionally, there was a significant correlation between not using an occlusal device and experiencing higher rates of minor chipping, access hole material being lost, and framework fracture.<sup>17</sup>

Another study by Papaspyridakos et al, focused on the results and potential complications associated with double full-arch implant prostheses.<sup>18</sup> In accordance with the study, there were 38 double full-arch IFCDPs, out of which 28 were MC and 10 were MR prosthesis. Survival rates of 92.1% were observed over a period of 5.1 years, with a range of 1 to 12 years. The most common significant technical issue was the breakage of the prosthetic material, with a dental-unit rate of 8.0% estimated over 5 years. The estimated cumulative rate for a prosthesis without technical complications over a span of 5 years was 57.1%. The study showed that not using a nightguard and having porcelain prosthetic material can increase the likelihood of chipping or fracturing in double full-arch

IFCDPs, particularly for individuals who suffer from bruxism.<sup>18</sup> In addition, another study about metal ceramic by Gonzalez et al. with a five-year follow-up period evaluated 80 full-arch implant supported metal porcelain prostheses that were implemented in 65 patients.<sup>2</sup> The study reported that there were several mechanical and technical complications associated with implant diameter, abutment and implant connection, and retention system. The loss of screw access hole filling and porcelain fractures were the most common prosthetic complications. Metal-ceramic prostheses for full-arch replacement have a high rate of survival for prosthesis.<sup>2</sup>

Furthermore, in a retrospective cohort study conducted by Papaspyridakos et al. in 2019 provided information about the rates of biological and technical complications associated with MC IFCDPs after an average period of observation lasting 5.0 years.<sup>19</sup> The study reported that after 5 years, the percentage of prostheses that were "free of minor technical complications" was 58.0%, while after 10 years, it dropped to 10.1%. On the other hand, after 5 years, the cumulative rate for prostheses that were "free of major technical complications" was 90.4%. However, after 10 years, this rate decreased to 49.1%. The study mentioned that one of the common minor technical issues observed was the wearing out of porcelain, which occurred at a rate of 8.0% per year. On the other hand, the most common major issue was the fracture of porcelain, which occurred at rate of 0.8% per year at the dental-unit level.<sup>19</sup>

It can be concluded that both hybrid prostheses and metal ceramic full arch are expensive, time-consuming to make, difficult to repair, and technique sensitive, preventing their usage for many patients.<sup>8</sup> Additional research is important to determine the financial

expenses associated with maintaining prosthetics for complete-arch implant rehabilitation.<sup>19</sup>

Advancements in regular dental procedures, such as prosthodontic treatments, are frequently influenced by the implementation of new dental materials and technologies. Various types of dental prostheses, including crowns, fixed dental prostheses, and removable prostheses, are made from different dental materials through a variety of dental laboratory techniques. Due to the widespread use of osseointegrated implants, fixed prostheses are now being used more often, even in situations where all teeth are missing.<sup>20</sup> With a recent shift in emphasis toward esthetics and patient-centered outcomes,<sup>3</sup> monolithic zirconia are now available clinically.<sup>21</sup>

The use of zirconia (ZrO<sub>2</sub>) as a high-performance ceramic can be traced back to a well-known study conducted by Garvie et al in 1975.<sup>22</sup> Zirconia is a type of crystalline dioxide made up of zirconium. It shares many mechanical properties with metals and has a color that closely resembles that of teeth.<sup>23,24</sup> Zirconia is a type of material that has three different crystal structures: monoclinic, tetragonal, and cubic.<sup>25, 26</sup> Zirconia undergoes a change in its crystal structure at different temperatures. From room temperature to 1170°C, it is in the monoclinic phase. Beyond that temperature, it changes to the tetragonal phase. Once the temperature reaches 2370°C, zirconia transforms into a cubic phase.<sup>23, 26</sup> To stabilize the tetragonal phase, it is possible to add metallic oxides like Y<sub>2</sub>O<sub>3</sub>, MgO, CeO, or CaO in small amounts.<sup>26</sup> The processes of grinding and sandblasting have the potential to cause a conversion from the tetragonal phase to the monoclinic phase.<sup>26, 27</sup> During the transformation, a volume expansion of 3% to 4% occurs, resulting in compressive stresses that effectively close the crack tip and halt any further propagation.<sup>26, 28</sup>

Y-TZP ceramics possess a unique characteristic called transformation toughening, which results in higher fracture strength and toughness when compared to other types of dental ceramics.<sup>23</sup> In 1969, the idea of utilizing zirconium oxide for medical purposes was initially suggested, particularly in the field of orthopedics. ZrO<sub>2</sub> was put forward as an alternative material for hip head replacement, replacing titanium or alumina prostheses. A study was conducted where ZrO<sub>2</sub> was placed in a monkey femur, and it was observed that there were no negative reactions.<sup>24</sup> Then, during the 1990s, zirconia was introduced to the field of dentistry and has become easily accessible through the use of computer-aided design and manufacturing (CAD/CAM) technology.<sup>25,29</sup> Clinicians have been encouraged to expand the use of zirconia ceramics for implant-supported restorations, thanks to its successful use in tooth supported restorations. Clinical studies have confirmed that zirconia is highly reliable as an abutment and framework material for implant-supported crowns and fixed dental prostheses.<sup>29,31</sup>

Zirconia has a low thermal conductivity, a low potential for corrosion, and good radiopacity. It is distinguished by a dense, monocrystalline homogeneity.<sup>24</sup> Tetragonal zirconia polycrystalline (Y-TZP) partially stabilized with yttrium oxide is renowned for having high flexural strength values (900–1200 MPa) and fracture toughness (9–10 MPa) due to a mechanism that makes it tougher through phase transformation.<sup>23,29,32</sup>

Y-TZP is a versatile material used in a variety of dental applications, including root canal posts, all-ceramic posterior tooth frameworks, implant-supported crowns and fixed dental prostheses (FDPs), custom made bars for supporting fixed and removable dental prostheses, implant abutments, and dental implants.<sup>29</sup>

Mundha et al. conducted a study comparing the wear of enamel against a metal ceramic crown, polished zirconia, and natural enamel. According to the study, in the premolar and molar regions, after a year, the wear of enamel against zirconia crowns was significantly lower than that of metal ceramic crowns.<sup>33</sup> When discussing the issue of bacterial adhesion, an aspect crucial to preserving zirconia restorations and avoiding marginal infiltrations and periodontal alterations, it was found to be significantly lower compared to other materials. Scarano et al. conducted a study that revealed a bacterial coverage rate of only 12.1% on zirconia, while titanium had a rate of 19.3%. In another study, Rimondini et al. supported these findings through an in vivo examination, which demonstrated that Y-TZP gathered fewer bacteria than Ti, with fewer potential pathogenic bacteria present.<sup>24</sup>

Because of its great biocompatibility, low bacterial surface adherence, high flexural strength, toughness due to a transformation toughening mechanism, and esthetic characteristics, zirconia has grown in favor in modern dentistry.<sup>21</sup> In addition, CAD/CAM zirconia restorations for manufacturing have revolutionized the way we approach restorative difficulties with complete-arch implant restorations, while using ceramic veneered zirconia frameworks is recommended for restoring complete-arch implant prostheses.<sup>34, 35</sup> Further investigation is required on the commonly reported issue of chipping in ceramic veneers, as well as the less frequent occurrence of framework failure.<sup>34, 36</sup> A retrospective study conducted by Papaspyridakos & Lal aimed to report on the 2 to 4 year clinical outcomes and technical complications associated with screw-retained porcelain fused to zirconia IFCDPs for edentulous patients. This was the first study to report on these results<sup>21</sup> of porcelain fused to zirconia IFCDPs can be used as a prosthetic treatment for 2-4 years, but may come with complications. The most common technical

issue is porcelain chipping or fracture, with a rate of 31.25%.<sup>21</sup> As an alternative to complete-arch fixed implant prostheses, the design and manufacture of monolithic zirconia prostheses offer a restorative solution. The uniform structure of monolithic zirconia prevents the occurrence of different interfaces, which reduces the risk of fractures or chips.<sup>34</sup> Because of these qualities, zirconia-based restorations have been introduced as an alternative to traditional porcelain fused to metal (PFM) restorations.<sup>21</sup>

However, two recent systematic reviews described the material's status as a promising alternative. According to Abdulmajeed et al, clinical research on the long-term outcome of zirconia CAFIPs is limited; however, the usage of monolithic zirconia is still associated with high short-term success.<sup>34</sup> When it comes to prosthesis survival rates and technical complications of monolithic zirconia implant supported fixed complete-arch dental prosthesis there is a lack of clinical evidence with implant-supported zirconia prostheses.<sup>34</sup>

Furthermore, Bidra conducted a systematic review with the aim of analyzing the clinical results of zirconia IFCDPs. The secondary aim was to compare the clinical results of monolithic zirconia with zirconia veneered with porcelain.<sup>37</sup> Based on current evidence, it has been found that Zir-IFCDPs have a minimal risk of failure in the short term. The use of monolithic zirconia with gingival stains or zirconia that is only veneered at the gingiva area is recommended to eliminate porcelain chipping. However, further long-term studies are required to validate these findings.<sup>37</sup>

Furthermore, a study conducted by Barootchi et al. compared the cost and clinical outcomes of zirconia full-arch implant-supported prostheses to metal-acrylic hybrids. The study found that zirconia prostheses are more expensive initially than metal-acrylic hybrids, but had lower complication rates. Maintenance and treatment for complications

did not significantly differ between two groups. The zirconia prostheses had satisfactory results and better survival rates.<sup>10</sup>

Additionally, a recent study by Pozzi et al. aimed to retrospectively assess the clinical reliability of fabricated zirconia IFCDPs. The study focused on rehabilitating patients with partial and complete edentulism who had used the prosthesis for up to 12 years.<sup>38</sup> Based on the findings, it can be concluded that a zirconia-based screw-retained implant-supported prosthesis is a dependable treatment choice for both partial and complete edentulism over a long period of time. There were no reported incidents of zirconia fractures, and only two prostheses required replacement, resulting in a cumulative prosthetic survival rate of 98.2%. Despite six instances of chipping fractures, the cumulative prosthetic success rate was reported to be 91.9%.<sup>38</sup>

Furthermore, in 2023 Thompson et al conducted a cohort study with the aim of determining the 1 and 5-year prosthesis complication and survival rates in patients who were rehabilitated with Zir-IFCDPs.<sup>39</sup> Out of the 67 arches treated with Zir-IFCDP, there were a total of 9 recorded failures. Three of these failures were due to framework fracture, 2 were due to patient-related concerns, 2 were due to implant loss, 1 was due to veneering porcelain fracture, and 1 had an unknown cause. Four of the failures happened when the opposing arch was also a Zir-IFCDP. According to estimates for the 67 arches of Zir-IFCDP, the one-year survival rate is 88.8% and the five-year survival rate is 72.5%.<sup>39</sup>

Moreover, choosing the most optimal treatment approach for edentulous patients from this variety of implant-prosthetic protocols provides a surgical and prosthetic challenge for dentists.<sup>40</sup> Treatment planning should ideally be based on the long-term scientific evidence

for these methods. Comparative studies, however, are still required to determine whether one therapy option is preferable to others.<sup>40</sup>

Complications in implant dentistry fall into two categories: biologic and technological. The term 'biologic complications' refers to disruptions in implant function caused by biological processes affecting the supporting peri-implant tissues,<sup>16</sup> while the term 'technical complications' refers to mechanical damage to the implant, implant components, and prosthesis. These technical issues following definitive prosthesis placement may not result in implant loss, but they may increase the number of repairs and maintenance sessions.<sup>16</sup> Only a few studies have attempted to quantify the expenses of IFCDPs and their maintenance.<sup>16</sup> From a socioeconomic standpoint, patient preference for specific treatment alternatives is based on the option's long-term efficacy as well as the related cost and maintenance.<sup>16</sup>

#### Aim /Objective

The primary objective of this study was to determine the prosthesis survival and complication rates associated with monolithic zirconia IFCDPs in completely edentulous patients following a minimum 1-year clinical follow-up.

#### Materials and methods:

This study was an observational single-center retrospective clinical cohort study performed in the Division of Postgraduate Prosthodontics at Tufts University School of Dental Medicine (TUSDM). A convenience sample of subjects that underwent treatment with zirconia IFCDPs at TUSDM was used in the present retrospective study. Descriptive statistics were calculated. SPSS v. 28 (IBM Corp., Armonk, NY, USA) was used in the analysis.

Inclusion Criteria:

- Only patients that had been rehabilitated at the Postgraduate Prosthodontic clinic of TUSDM will be included.
- Age of the patient > 18 years old at time that they received treatment.
- Rough surface dental implants.
- Only completely edentulous patients that have been rehabilitated with monolithic or modified monolithic zirconia IFCDPs at one edentulous jaw at least.
- A minimum of 1 year under functional loading.

Exclusion Criteria:

- Patients who do not meet inclusion criteria.
- Patients with less than 1 year since the insertion of the final prosthesis.
- Patients who do not wish to sign the informed consent form.
- Pregnant females will be excluded due to dental x-rays, as is standard of care at TUSDM. When contacted about participation, female subjects were asked if they are pregnant. If they were pregnant, they were invited to participate after the pregnancy.

Only completely edentulous patients who had received rough surface implants were eligible for inclusion into the study. The completely edentulous patients have already received a zirconia IFCDP. Implant surgeries followed established surgical principles, which had been followed at TUSDM. All implant surgeries were performed either by faculty or by postgraduate residents under supervision by faculty.

**Definitions:**

Prosthesis survival was defined as prosthesis remaining in situ with or without modifications during the entire observation time.<sup>18</sup>

Success was defined as an implant-supported FDP being free of all complications over the entire observation period.<sup>41</sup>

Failure was defined as restoration having been removed or failure was defined as an event leading to the loss of the prosthesis.<sup>36</sup> The need to renew the entire implant-supported prosthesis as well as reported “repairs”; and The explantation/loss of the implant and therefore also the loss of the implant-supported prosthesis.<sup>42</sup>

The California Dental Association rating system for quality was used to characterize ceramic failures as either acceptable (surface is deficient but can be polished) or unacceptable (surface is fractured and restoration must be repaired or replaced). For simplicity, the previous descriptions were replaced by the terms porcelain chipping (minor complication) and porcelain fracture (major complication).<sup>18</sup>

**Technical complication:**<sup>16, 18, 36</sup>

Technical complications:

Wear of the prosthetic material

Chipping of prosthetic material

Loss of screw access filling

Loosening of a screw

Loosening of an abutment screw

Fracture of the prosthetic material

Framework fracture

Fracture of a screw

Fracture of an abutment

Fracture of an implant

Fracture of the opposing restoration,

Patient dissatisfaction

#### E) Study Procedures

##### *Visit 1 (Approximately 1-1.5 hours):*

The subject was instructed to read the informed consent form (ICF). Subject was given a sample time to have any questions answered. If a subject decides to participate, he or she was instructed to sign the ICF. A copy of the ICF was given to the subject.

Subject was asked to complete demographic information and a medical history. Eligibility criteria will be evaluated.

Full set of intraoral photographs was taken. It consisted of intraoral views in maximum intercuspation (frontal and lateral) and intraoral views of maxillary and mandibular arches (frontal, buccal, palatal and occlusal). The photographs were used to identify technical complications (chipping, wear).

All of the following evaluations were done routinely at a recall appointment, however, are being done at this visit as part of the research study.

An oral exam, including evaluation of oral cavity, soft and hard tissues, will be completed following standard of care procedures in US dentistry using a mouth mirror, periodontal probe and dental explorer.

In detail, the following prosthodontics parameters were assessed:

1. Presence/absence of an IFCDP,
2. Jaw and location,
3. Number of replaced teeth and number of abutments,
4. Location of implants and number of prosthetic segments (if not 1-piece),
5. Prosthetic materials used to fabricate the prosthesis,
6. Presence of a mesial/distal cantilever extension,
7. Presence/absence of nightguard,
8. Presence/absence of bruxism,
9. Type of opposing dentition,
10. Occlusal scheme,
11. Wear of prosthetic material,
12. Fracture of prosthetic material (chipping)

Regarding occlusal scheme, the occlusion were assessed as either mutually protected occlusion with anterior guidance or with group function. Attrition or wear were estimated as absent, localized, or generalized. The opposing dentition will be categorized according to the presence of naturally restored or unrestored teeth, implant-supported restorations, or removable partial denture.

Digital periapical radiographs of each implant were obtained from the subject except if they already exist within a period of 6 months prior and without any change in clinical status since last visit.

Radiographs will be taken following standard of care methods (including wearing a lead apron to reduce unnecessary exposure).

During the clinical examination, the IFCDPs were also examined for any complications or failures. If subjects were in need of treatment due to complications, then they were informed about it. The patients were given the choice whether they prefer to be treated at TUSDM for the complications, at normal clinic fees, if they were still TUSDM patients attending the recall, or they prefer to be referred back to their dentists if they were not TUSDM patients anymore. All evaluations were following standard of care guidelines.

*After Visit 1:*

Record review of the subject's AxiUm dental chart were done after the completion of the study visit to record complications or failures that had occurred prior to the single research visit. They were defined as follows: Short-term if they happened within 1-3 years, mid-term if they happened within 3-5 years and long-term if they happened after 5 years since definitive prosthesis insertion. The definitive prosthesis insertion is the time baseline.

## Results

This study included a convenience sample of 14 individuals. The age of participants varied, with a mean of 67.6 years and a range of 35 to 80 years. Four individuals (28.6%) identified as female and ten individuals (71.4%) identified as male. All participants identified as white and non-Hispanic. Only one participant (7.1%) self-reported as a smoker and the same percentage was observed for self-reported diabetes. None of the participants reported to have undergone jaw irradiation, have a history of cancer, or have used bisphosphonates.

Regarding dental conditions and treatments, the study explored various variables. A majority of the participants (85.7%) reported not using a nightguard, while 14.3% indicated using one. Bruxism, a condition characterized by teeth grinding or clenching, was reported by 21.4% of the participants, while 78.6% did not report having the condition. The distribution of opposing dentition among the participants was as follows: 28.6% had natural dentition, 21.4% had implant-supported dentition, 21.4% used removable prosthesis, 21.4% had a combination of teeth and implants, and 7.1% had an implant overdenture.

In terms of specific dental treatments, 80.0% of the IFCDPs did not have a cantilever, while 20.0% had a cantilever. Among the participants, 60.0% of 20 monolithic zirconia IFCDPs were made in the maxilla, and 40.0% in the mandible. Regarding prosthesis types, all participants (100%) had an abutment level prosthesis. The number of teeth in the participants varied, with 95% having 12 units, and only 5% having 13 units. Similarly, the distribution of abutments and implants was mostly uniform, with 95% of

participants having 6 abutments and 6 implants, and only 5% having 5 abutments and 5 implants.

The mean duration of prosthesis use was approximately 36.8 months, with considerable variation (SD = 21.6 months). There was no prosthesis failure in this study (100% survival rate of the prosthesis), i.e., there were no failures reported in this study.

Participants experienced very few major complication events (mean = 0.05 events, SD = 0.22 events), and the majority did not encounter any major complications (median = 0 events). Minor complications were slightly more common (mean = 1.15 events, SD = 1.2 events), with variability in occurrence (median = 1 event, IQR = 0.0 events to 2.0 events). Combining major and minor complications, the mean total number of complications was 1.2 events (SD = 1.2 events), with some variability among participants (median = 1 event, IQR = 0.0 events to 2.0 events).

Among the minor technical complications that were found, "Occlusal Wear" "Chipping" and "Loss of Access Hole Material" emerged as the most prevalent, occurring in 25.0%, 20.0% and 20.0% of cases, respectively. Encouragingly, "Loosening of Abutment" did not manifest in any of the participants, signifying a positive outcome in this aspect. The occurrence of "Fracture of Veneer" was also relatively infrequent, affecting only 5.0% of cases, with an overwhelming majority (95.0%) experiencing no such complication. Several other complications, including "Screw Loosening," "Wear of Prosthetic Screw," and "Decementation, of the ti-bases" were observed in smaller percentages of 10.0%, 15.0%, and 15.0%.

The major complications "Fracture of an Abutment," "Fracture of Framework," and "Fracture of Implant" did not occur in any of the 20 cases (100.0% for all). However, in

the case of "Fracture of Screw," one instance of occurrence was recorded, representing 5.0% of the cases. The study recorded a total of 23 minor complication events and 1 major complication event.

### **Discussion:**

Zirconia has gained significant popularity in modern dentistry due to its favorable properties, such as biocompatibility, low bacterial surface adherence, high flexural strength, toughness through a transformation toughening mechanism, and esthetic appeal. The advent of CAD/CAM zirconia restorations has revolutionized the approach to restorative challenges, particularly in complete-arch implant restorations. Zirconia frameworks are recommended for restoring complete-arch implant prostheses, and the design and manufacture of monolithic zirconia prostheses offer a viable restorative solution. The homogenous structure of monolithic zirconia minimizes the occurrence of different interfaces, thereby reducing the risk of fractures or chips.

In light of these qualities, zirconia-based restorations have emerged as an alternative to traditional porcelain fused to metal (PFM) restorations. However, selecting the most optimal treatment approach for edentulous patients from the range of implant-prosthetic protocols presents a surgical and prosthetic challenge for dentists. Treatment planning should ideally rely on long-term scientific evidence for these methods. Comparative studies are still needed to determine whether one therapy option is preferable to others.

The primary objective of this study was to determine the prosthesis survival and complication rates associated with monolithic zirconia IFCDPs in completely edentulous patients after a minimum 1-year clinical follow-up.

This study included a sample of 14 individuals with 20 arches of monolithic zirconia IFCDPs and a mean age of 67.6 years, ranging from 35 to 80 years. In addition, the mean duration of prosthesis use was approximately 36.8 months.

Our results reported 100% survival rate of the monolithic zirconia IFCDPs. However, complications did exist. The minor technical complication encountered includes occlusal wear, chipping, and access hole material loss as the most common, with occlusal wear leading at 25%, followed by 20% for both chipping and access hole material loss at the prosthesis level. Notably, the only major complication reported was screw fractures, occurring at a rate of 5%.

This study contributes significant insights into the technical complications associated with dental prostheses, offering opportunities for enhanced patient care and refined treatment approaches. Also, in the present study minor complications were considered as those that could be addressed and repaired by the clinician intraorally or chairside, while major complications were those that could be addressed or repaired by the clinician in the dental chair and require a more extensive approach.

The study revealed that participants experienced few major complications, and most did not encounter any major complications. Minor complications were slightly more common but also showed variability. Combining major and minor complications, the mean total number of complications was relatively low, with some variation among participants.

With regard to minor complications, the most prevalent minor technical complications were "Occlusal Wear" "Chipping" and "Loss of Access Hole Material." "Loosening of Abutment" did not occur in any participants, which was a positive outcome. The occurrence of "Fracture of Veneer" was relatively infrequent, with the majority not experiencing this complication. Other complications, such as "Screw Loosening," "Wear of Prosthetic Screw," "Decementation of the ti-bases," and were observed in smaller percentages.

In the present study, chipping of the porcelain material was reported in 20% (4 out of the 20 arches) of the cases. It was in the incisal edges or around the ti-bases and one fracture of the veneered porcelain was reported; both complications were considered as minor complications since the prosthesis needed to be repaired and polished instead of replacing it. A similar study by Tischler et al. showed no chipping of the veneered material since it was veneered with gingival porcelain and limited to non-load-bearing functions.<sup>45</sup> Similar results were reported by Bidra et al. when the porcelain was limited to the gingival surface.<sup>8</sup> A study by Thompson et al. found that veneering porcelain on facial surfaces led to minor chipping.<sup>39</sup> Comparing our results with Pozzi et al., Papaspyridakos & Lal, Bidra et al, and Gonzalez et al, similar results were observed regarding chipping of the veneer of the material when it was in the facial aspect of the teeth.<sup>2, 21, 37, 38</sup> It is recommended to avoid facial cutback or veneering with porcelain on the facial surface to reduce the risk of chipping or fracture complications. Instead, employing a monolithic prosthesis or adding the veneering material solely on the gingival surface is suggested. However, due to the limited sample size in this study, establishing a direct correlation between bruxism or the use of a night guard and material chipping was challenging. Furthermore, no other study

has reported chipping of the material around the ti-bases, but such occurrences were observed in our study results.

Moreover, another minor technical complication was observed. The present study indicated that debonding of the ti-bases occurred in 15% of the cases, with a total of 3 incidents recorded. Tischler et al. reported a debonding incidence of 1 ti-base out of 191 prosthesis cases<sup>45</sup>. In a systematic review study conducted by Abdulmajeed et al., it was revealed that among the examined prosthesis cases, one ti-base experienced debonding.<sup>34</sup> In contrast, the findings from the current study demonstrated a higher prevalence of debonding incidents. Furthermore, Bidra et al. conducted a retrospective lab chart review study involving 2039 zirconia prostheses; during the chart review, a minimum of 319 prostheses had been delivered from the lab to the clinician and had been inserted for a duration of at least 3 years. The chart review analyzed the re-dos and the repairs from the same lab that were necessary for those 2039 prostheses. The chart analysis revealed that six prostheses experienced debonding of the Ti-bases, and an additional three prostheses were returned due to fracture of the Ti-bases<sup>8</sup>. Fracture of the ti-bases was not reported in our study. In addition, a study done by Gonzalez et al. reported two debonding of the Ti-bases and it was the second most common technical complication found in their study.<sup>2</sup>

Furthermore, Gonzalez et al. mentioned that Ti-bases debonding can result from various factors, such as the zirconia surface lacking sufficient bonding properties, insufficient room for the thickness of the cement film, limited light diffusion through the zirconia for activating dual-cured luting agents, and insufficient resistance and form of the metal insert itself.<sup>2</sup>

One of the recommended approaches for reducing the occurrence of debonding is to adhere to the manufacturer's guidance, as proposed by Bidra et al. This entails using the implant manufacturer's titanium cylinders bonded to zirconia, creating a metal-to-metal interface over the implants or abutments.<sup>8</sup>

In this study, the most prevalent minor complications were "Occlusal Wear" "chipping" and "Loss of Access Hole Material," occurring in 25.0%, 20.0%, and 20.0% of cases, respectively. Interestingly, the specific complication of occlusal wear had not been reported in other studies to our knowledge. However, the assessment of occlusal wear posed certain limitations as it was challenging to differentiate between natural wear and prior adjustments made for occlusal purposes. Additionally, the small sample size precluded the ability to establish associations with factors like bruxism or the use of nightguards. The wear was most commonly noticed when opposing the natural dentition.

Upon comparison with our study's findings on the loss of access hole material, a similar result was reported by Carames et al. In their study, this complication was also identified as the most common technical issue, despite their study having a longer follow-up period and a larger sample size.<sup>46</sup>

Among the 20 arches examined, several other complications were observed in smaller percentages, with "Screw Loosening" occurring in 10.0% and "Wear of Prosthetic Screw" accounting for 15.0%, corresponding to 2 and 3 incidents, respectively. When comparing our study's findings regarding screw loosening with those of Carames et al., a similar outcome was observed. In their study, screw loosening was also identified as a

common technical complication<sup>46</sup>. Regarding the wear of the prosthetic screw, no other study has reported such a complication.

Fortunately, no instances of "Loosening of Abutment" were detected among the participants, reflecting a favorable outcome in this regard. However, it is essential to note that other studies have documented cases of abutment loosening. For instance, Abdulmajeed et al. identified one case of loose abutment in their systematic review of prosthesis cases,<sup>34</sup> and Bidra et al.'s review of 285 prosthesis cases revealed two instances of loose abutments<sup>37</sup>. The reasons or explanations for these occurrences were not mentioned in the context of this study. Based on our findings, the occurrence of minor technical complications was generally low and aligned with what has been documented in the current literature, with the exception of occlusal wear.

The study assessed major technical complications, specifically "Fracture of an Abutment," "Fracture of Framework," "Fracture of Implant," and "Fracture of Screw."

The majority of cases did not experience these complications, except for "Fracture of Screw," which occurred in a small number of instances.

In this study, the occurrence of screw fracture was reported once, and the issue was promptly addressed in the clinic by replacing the damaged screw with a new one. The observed incident took place in a patient who had the prosthesis for 5 years. Notably, Tischler et al. also reported the same issue of screw fracture twice in their study<sup>45</sup>, despite having a larger sample size and a longer follow-up period. Our study showed a lower incidence of such incidents in comparison to Tischler et al.'s study.

In our study, no occurrences of abutment fracture were observed. However, in similar studies, such as Bidra et al.'s systematic review, two abutments were reported to have fractured<sup>37</sup>, and Abdulmajeed documented one case of abutment fracture<sup>34</sup>.

One of the potential factors contributing to prosthesis failure is the occurrence of framework fractures or implant fractures. However, in our study, no such incidents were reported, considering the limited sample size and relatively short follow-up period. Consequently, our study demonstrates a notably reduced number of major technical complications, indicating a 100% survival rate for the 20 prostheses throughout a mean prosthesis use duration of approximately 36.8 months. When comparing our study's results with other literature, we observed a higher survival rate, as none of the prostheses required replacement due to fracture. This outcome aligns with a similar study conducted by Papaspyridakos & Lal, who also reported a 100% survival rate in a 4-year follow-up period.<sup>21</sup>

In contrast, Tischler et al.'s study involving 191 prostheses reported that a total of 3 zirconia complete-arch fixed implant prostheses required remaking due to implant failures, and an additional one zirconia prosthesis needed remaking due to fracture. This resulted in a 4-year cumulative survival rate (CSR) of 97.6%<sup>45</sup>. Furthermore, both our study and the study conducted by Papaspyridakos & Lal demonstrated higher survival rates when compared to Barootchi et al. In the latter study, two cases of zirconia fractures were reported.<sup>10, 21</sup>

Additionally, Limmer et al. conducted a study with a follow-up period similar to ours, reporting a prosthesis survival rate of 88% over one year. In their study, one prosthesis needed replacement due to fracture, and another due to implant failure. The

study highlighted that the occurrence of fractures may be attributed to various factors, including cantilever length, anterior-posterior (A-P) spread, restorative dimension, and material properties of zirconia, which can involve several variables<sup>47</sup>. Furthermore, the most recent study published about zirconia full arch implant prostheses with a total of 67 had a lower survival rate of 73% at 5 year and 89% at 1 year; the primary cause for prosthesis replacement was fracture of the zirconia framework, accounting for 4.4% of all units. These fractures were consistently associated with limited vertical restorative space. However, the specific criteria or minimum requirements for adequate restorative space were not explicitly mentioned in the study.<sup>39</sup>

### **Limitations:**

One limitation of this study is the small sample size, consisting of 14 participants with 20 prostheses. This may limit the generalizability of the findings to a larger population. Additionally, the mean follow-up period of approximately 36.8 months may not be sufficient to capture long-term complications or changes in prosthesis performance. Due to the small sample size, it was not possible to establish statistically significant associations between variables and potential factors contributing to complications. Larger studies with longer follow-up periods are recommended for more conclusive results.

### **Conclusion:**

Within the limitations of the present study, monolithic zirconia IFCDPs demonstrated a favorable prosthetic option after minimum one year of use, with a 100% survival rate.

However, complications did exist. The minor technical complication encountered includes occlusal wear, chipping, and access hole material loss as the most common, with occlusal wear leading at 25%, followed by 20% for both chipping and access hole material loss at the prosthesis level. Notably, the only major complication reported was screw fractures, occurring at a rate of 5%.

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APPENDICES

**Appendix A:**

**Table 1: Demographics**

Demographics:		
	Mean	SD
Age	67.6	11.8

Variable		Sample Size N	Percentage
<b>Gender</b>	female	4	28.6%
	Male	10	71.4%
<b>Race</b>	White	14	100%
<b>Ethnicity</b>	Non Hispanic	14	100%

**Table 2: Lifestyle and medical history**

Lifestyle and Medical History			
Variable		Sample Size N	Percentage
<b>Smoking</b>	No	13	92.9%
	Yes	1	7.1%
<b>Diabetes</b>	No	13	92.9%
	Yes	1	7.1%
<b>Jaw irradiation</b>	No	14	100%
<b>Cancer</b>	No	14	100%
<b>Bisphosphonates</b>	No	14	100%

**Table 3: Prosthesis related factors:**

Variable	Category	Sample size N	Percent (%)
<b>Nightguard use</b>	No	12	85.7%
	Yes	2	14.3%
	Total	14	100.0%
<b>Bruxism</b>	No	11	78.6%
	Yes	3	21.4%
	Total	14	100.0%
<b>Opposing dentition</b>	Natural dentition	4	28.6%
	Implant supported	3	21.4%
	Removable prosthesis	3	21.4%
	Mixed "teeth and implant"	3	21.4%
	Implant overdenture	1	7.1%
	Total	14	100.0%
<b>Cantilever</b>	No	16	80.0%
	Yes	4	20.0%
	Total	20	100.0%
<b>Jaw</b>	Maxilla	12	60.0%
	Mandible	8	40.0%
	Total	20	100.0%
<b>Abutment level prosthesis or implant level prosthesis</b>	Abutment level	20	100.0%
<b>Number of teeth</b>	12.00	19	95.0%
	13.00	1	5.0%
	Total	20	100.0%
<b>Number of abutments</b>	5.00	1	5.0%
	6.00	19	95.0%
	Total	20	100.0%
<b>Number of implants</b>	5.00	1	5.0%
	6.00	19	95.0%
	Total	20	100.0%

**Table 4: Minor technical complications**

Minor technical complications		Sample Size (20)	Percent
Occlusal Wear	No	15	75.0
	Yes	5	25.0
Loss of Access Hole Material	No	16	80.0
	Yes	4	20.0
Loosening of Abutment	No	20	100.0
Chipping	No	16	80.0
	Yes	4	20.0
Fracture of Veneer	No	19	95.0
	Yes	1	5.0
Screw Loosening	No	18	90.0
	Yes	2	10.0
Wear of Prosthetic Screw	No	17	85.0
	Yes	3	15.0
Decementation	No	17	85.0
	Yes	3	15.0

**Table 5: Major technical complications**

Major technical complications		Sample Size (20)	Percent
Fracture of an abutment	No	20	100.0
Fracture of framework	No	20	100.0
Fracture of implant	No	20	100.0
Fracture of screw	No	19	95
	Yes	1	5.0

**Table 7: Descriptive analysis**

	Mean	Median	SD	IQR
Months with prosthesis	36.8	27.5	21.6	(16.0,58.3)
Number of major complication events	0.5	0	0.22	(0.0,0.0)
Number of minor complication events	1.6	1	1.2	(0.0,2.0)
Total number of complication events	1.2	1	1.6	(0.0,2.0)

**Appendix B:**



Figure 1 : Decementation of the MUA ti-base



Figure 2: Loss of access hole material

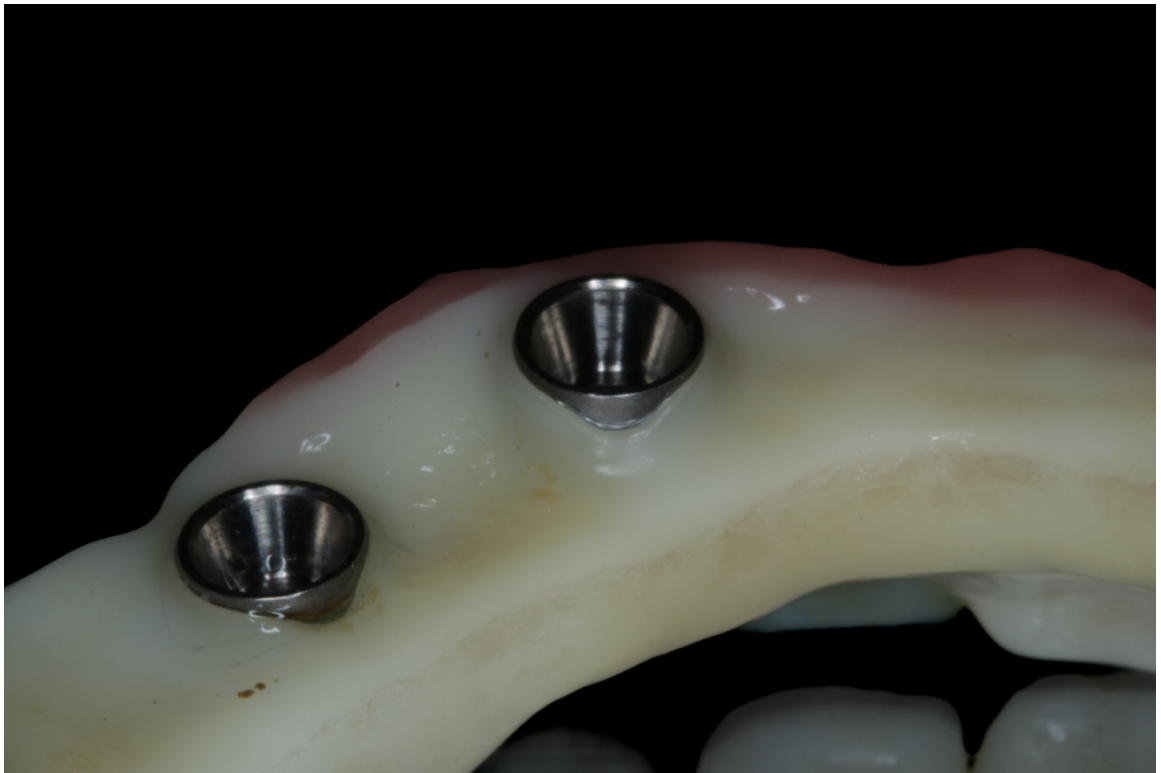


Figure 3: Chipping around the ti-bases



Figure 4: Fracture of the veneer material.