Prosthetic Complications of Implant-Fixed Complete Dental Prostheses

BY

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THESIS

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LIST OF ABBREVIATIONS

CAD-CAM	Computer-assisted design, computer-assisted manufacture
IFCDP	Implant-fixed complete dental prosthesis
IRB	Institutional review board
OHIP	Oral health impact profile
OHQoL	Oral health-related quality of life
PFM	Porcelain-fused-metal
PFZ	Porcelain-fused-zirconia
QoL	Quality of life
SD	Standard deviation
SPSS	Statistical product and service solutions
Y-TZP	Yttria-stabilized tetragonal zirconia polycrystal

1. INTRODUCTION

1.1 Background and Significance

With the success of osseointegrated dental implants, there are an increasingly large number of restorative options available to the edentulous patient [1, 2]. Numerous studies have demonstrated high rates of implant success [3-7], as well as low incidence of biological complications associated with implant-supported prostheses [8-11]. As dental implants have become a widely accepted treatment modality, scientific studies can now focus on the complications associated with implant prostheses, instead of primarily on the biological and technical complications associated with the implant substructure. Complication profiles of the different implant-supported complete dental prostheses (IFCDPs) are not well-characterized, and only one study has examined complications across different types of full arch prostheses [12].

Unlike other types of IFCDPs, metal-acrylic hybrid dentures have a history as long and rich as dental implants themselves. Ten and fifteen year follow-up studies were published in the early 1980s [3]. In many ways, these first prostheses were very similar to metal-acrylic prostheses made today [13]. Although these prostheses were almost exclusively limited to the mandible, the design was very similar to metal-acrylic prostheses fabricated today. They involved the placement of six intraforaminal

implants to which a screw-retained bar with a distal cantilever was attached, and denture teeth connected to the metal framework with acrylic resin. Initially, the most significant concerns about these prostheses were in regards to esthetics, phonetics, and hygiene [14]. While esthetics have improved dramatically, long-term follow-up has shown that these prostheses exhibit significant prosthetic tooth wear and fracture, as well as fracture of the veneering acrylic [15, 16].

The advent of CAD/CAM technology has dramatically increased the ease with which more complex, full-arch prostheses can be fabricated. In an effort to utilize this new technology, as well as to overcome many of the complications associated with metal-acrylic prostheses, Maló suggested a technique in which all-ceramic crowns could be cemented onto milled titanium bars [17]. Ideally, this would allow for improved esthetics, biomechanics, hygienic maintenance, and long-term prognosis [17]. Additionally, the cementable crowns offered retrievability and repairability, as well as closure of screw access holes, all of which were not possible with metal-ceramic frameworks to which porcelain was veneered directly. While survival of the prostheses was high, chipping of the ceramic crowns occurred in nearly 50% of patients, particularly in instances where the prosthesis opposed a metal-ceramic implant-supported fixed prosthesis [17].

In an effort to produce prostheses less susceptible to wear and fracture, the use of zirconia for implant-supported complete dentures has been explored. Zirconia has been utilized in many areas of dentistry, including single crowns, fixed dental prostheses, and implant abutments, with varying degrees of success and acceptance within the dental community [18]. Several years ago few studies had examined the use of zirconia milled complete dentures [19, 20]. However, with improved understanding of their handling properties and rapidly improving results, their popularity has exploded in recent years. Despite the increased strength of zirconia over porcelain and acrylic, the veneering porcelain used to improve esthetics has a tendency to chip and fracture [12, 21, 22], and catastrophic failure has also been seen [23-25]. Due to the minimal number of studies of both retrievable crown and milled zirconia prostheses and the varying treatment protocols, comparisons regarding the incidence of prosthetic complications between the two types of prostheses are challenging.

As the quality of dental prostheses continually improves, there has never been a more important time to include patient feedback and patient-centered outcomes in the evaluation of different treatment modalities [26, 27]. This data can be gathered through validated patients' oral health-related quality of life (OHQOL) assessments and through targeted patient interviews. The Oral Health Impact Profile (OHIP) is one

of the most commonly used standardized instruments to assess the impact of different types of dental prostheses [28]. Importantly, OHIP has been validated, demonstrating both high internal reliability as well as test-retest reliability [29]. The second method of gathering patient feedback is through the use of a structured patient interview, as this allows patients a means of providing qualitative information about their experiences and provides a deeper understanding of our particular research question.

1.2 Specific Aims

The specific aims of this research study were: 1. To identify the frequency and severity of complications associated with different types of implant-supported fixed complete dental prosthesis (IFCDP); 2. To identify specific complications associated with each type of full-arch implant-supported prosthesis; and 3. To compare patient satisfaction and the effect on oral health care related quality of life with different IFCDP designs.

1.3 Hypotheses

1. Metal-acrylic implant-fixed complete dental prostheses will have the most complications.

2. Since complications with metal-acrylic IFCDPs can also be most easily repaired, they will have the fewest failures.

3. OHQoL will be the highest for patients with retrievable crown and milled zirconia prostheses with veneering porcelain, since they prostheses have improved material properties over metal-acrylic.

2. REVIEW OF LITERATURE

2.1 Metal-Acrylic Prostheses

According to some of the earliest published articles on osseointegrated dental implants, unlike complete dentures, implant-anchored fixed prostheses offered a means to restore patients to a masticatory function equal to or approaching those of dentate persons [3]. Such therapies could not only provide functional rehabilitation, but also aid in the rehabilitation of the person from the medical, social and psychiatric perspectives [3]. It was suggested that implant-supported fixed prostheses were indicated when:

1. There was extreme bony resorption resulting in inadequate denture retention.
2. The patient was mentally unable to accept a removable prosthesis, whether or not it was well-fabricated.
3. The patient experienced functional disturbances such as severe nausea or gagging when using a denture [3].

In many ways the treatment protocols were similar. Four to six implants were placed using a two-stage procedure. After three to six months, the implants were uncovered and healing abutments placed. After two weeks, final impressions were taken and a precise, passively fitting gold bar was designed to be veneered with acrylic and attached to the implants. The recommended design allowed for a distal cantilever of no more than two teeth in the mandible and one tooth in the maxilla.

Care was also taken to provide only a convex tissue surface that allowed sufficient periabutment space for hygiene [3].

While these studies clearly identified that implant-fixed complete dental prostheses (IFCDPs) were a viable treatment option, they were not without complications [3]. An article published by Adell et al. in 1981 identifies rapid marginal bone loss (approximately 3 mm per year) and bridge fracture as the most common complications at 8.0% and 4.9%, respectively [3]. However, as implant surfaces began to improve and biological complications were becoming less common, it seemed as if the incidence of prosthetic complications was increasing. In 1990 Johansson reported that the incidence of fracture of the acrylic teeth was 22% [30]. Hemmings identified peri-implant soft tissue inflammation as the most common complication, as it was noted 27 times over the course of a 5-year recall period in 25 patients. Of complications with the prosthesis itself, gold abutment screw fracture was noted 11 times in 25 patients and acrylic-resin fracture in 9 [31]. In the same year, Carlson and Carlsson reported that the most common complications were related to the acrylic resin part of the prosthesis, with 60% of prostheses having some problem with the acrylic resin matrix, with many of the prostheses having been in service for only 2-3 years [32].

Over the years, IFCDPs had become a common treatment modality with an abundance of research demonstrating its viability as an alternative to conventional

prosthetic treatment modalities. However, complications with the suprastructure continued to be common. Nearly a decade later Gothberg similarly reported that fractures of the acrylic resin matrix and acrylic teeth were the most common complication. They noted that 23% of patients returned to the clinic with the chief complaint of fractured acrylic resin matrix [30, 33].

Now, over thirty years since the first literature was published on IFDCPs, dramatic improvements have been made with metal-acrylic prostheses. The current literature demonstrates that implant fractures and failures are rare [16]. Additionally, framework complications have largely been resolved with the introduction of milled titanium bars. Purcell states that the initially high incidence of framework fracture can be attributed to a learning curve in fabrication of the restorations, including the use of type III gold alloy for the framework and a small cross-sectional dimension distal to the posterior implant. Once these issues were corrected, further complications with the framework were significantly reduced. Similarly, the high incidence of screw loosening was primarily reported in studies that used gold alloy retaining screws and has been greatly reduced, particularly in the short-term with the use of titanium-alloy screws instead of gold [16].

However, the short-comings of acrylic as a prosthetic material remain. In a study published in 2008 of 46 patients with mandibular metal-acrylic IFCDPs opposing complete dentures, Purcell found that even when opposing removable

prostheses, prosthetic tooth fracture was the most common complication with 9 incidences of tooth fracture for the 46 prostheses in less than two years and 28 fractures after 5 years [16].

After five years, the second most common complication for the IFCDP itself was the need for tooth replacement due to excessive occlusal wear. For the purposes of their study, excessive occlusal wear was defined as significant loss of cuspal and occlusal anatomy of the acrylic teeth. Replacement of the acrylic teeth due to wear was recommended in 24 of 46 prostheses after five years [16].

Fischer and Stenberg summarize the prognosis of metal-acrylic prostheses nicely in their study of 23 patients with maxillary metal acrylic prostheses with a 10-year follow-up. No implants had failed and only one metal framework had fractured, as is consistent with more recent studies. However, only 9% of the prostheses could be classified as having been successful. Although 82% survived, 9% failed. They noted 4.7 complications on average throughout the 10 years of service, of which tooth fracture was the most common [34]. From these articles it is clear how important it is to understand the limitations of metal-acrylic implant-supported prostheses when treatment planning and helping to set realistic expectations for our patients.

2.2 Retrievable Crown Prostheses

A fundamental aspect of an IFCDP is that it requires a passively fitting metal substructure. When supporting acrylic denture teeth, the design of the bar can be relatively simple and thus the challenges of casting can be kept to a minimum. The essential structural parameters are to maintain an adequate cross sectional area, minimized the cantilever, and provide sufficient clearance for the acrylic teeth. However, when providing support for a stronger material, such as porcelain, a more structurally complex bar fabricated from cutting back a full contour prosthesis is required. Casting such a substructure provides a much greater challenge and usually requires sectioning the components and subsequently soldering the parts back together. However, this is not only time-consuming, but also an inexact procedure [35].

The advent of computer-assisted design (CAD) and computer-assisted milling (CAM) and its adaptation to dental restorations by Nobel Biocare was a huge technological advancement in that it allowed titanium substructures to be milled precisely, free from defects and distortions. This precision made the fabrication of more complex and predictable substructures possible with relative ease [35]. However, utilization of a titanium bar also requires different laboratory techniques. Due to challenges associated with bonding porcelain to titanium in a predictable

manner, full contour crowns cemented onto the titanium bar are necessary in order to utilize ceramic as the restorative material.

Piermatti first published a case report on this technique, which advocated the use of milled, titanium bars as they provide a more accurate and intimate fit to the implant platform, as well as being stronger and more lightweight. He also proposed that full contour crowns provide a means of covering access holes that may exit buccally while still eliminating cement use through the incorporation of lingual set screws [35].

In 2012 Paulo Maló published a prospective study of 108 patients restored utilizing a similar technique – milled titanium frameworks with individually cemented all-ceramic crowns. He argued that there is a need for research focused on innovative types of frameworks, fabrication techniques, and their predictability. He stated that the two main reasons for complications with implant-supported prostheses are lack of passive fit between the restorations and the abutment and the presence of destructive occlusal contacts. As mentioned previously, while frameworks fabricated using a lost wax/casting technique are a proven technique, they have limitations in the precision of fit. He advocated that the CAD/CAM system provides the advantages of a precise fit, the possibility of extended cantilever lengths, biocompatilibility, the lack of rigid connectors such as solder or welded joints within

the CAD/CAM framework, and that it is machine manufactured, and thus less susceptible to procedural errors [17].

The second major challenge facing implant-supported fixed prostheses is ceramic fracture, or more generally destruction of the occlusal surfaces. This complication poses a particular challenge when the ceramic has been applied to a gold alloy substructure. While adding additional ceramic and refiring the prosthesis can be possible, it may increase the probability of damaging the connectors or causing fractures in the ceramic due to an increased number of firing cycles. However, despite this risk, evidence does support the use of ceramic in implant-supported prostheses. Ceramic has many obvious advantages over acrylic including excellent esthetics, high fracture resistance, maintenance of vertical dimension, increased longevity, improved hygiene and stain resistance, and the opportunity for customization [17].

Theoretically, the use of titanium bars with cementable crowns provides high esthetics, ease of repair (individual crowns can be replaced without having to remove or refire the entire prosthesis), and a cushion effect [17]. Additionally, it provides the ability to mask implant screw-access, which has been angled too far buccally. However, while the concept is elegant and the prosthetic survival was demonstrated to be almost 100%, the incidence of complications was also very high. Mechanical complications occurred in 55% of prostheses having been restored with Allceram®

crowns and pink ceramic gingiva and in 27% of prostheses restored with porcelain-fused-zirconia (PFZ) crowns and pink acrylic resin gingiva, most of which were chipping and fracturing of the crowns [17].

Despite flaws the technique has merit when some modifications are made. Maló published a case report in 2014 of the same technique, but of a maxillary prosthesis with e.max® monolithic restorations which, instead of opposing the same material, was placed into occlusion against a metal-acrylic IFCDP. In the 18 months of follow-up, no biological or mechanical complications occurred [36]. Pozzi et al. also published a report of 16 patients receiving 18 arches of IFCDPs, also with monolithic lithium disilicate restorations, but on milled zirconia frameworks. Additionally, all maxillary incisors and canines were veneered with layering porcelain. After three years of follow-up, the survival rate was 100% and only one restoration (a veneered anterior restoration) had chipped and required polishing [37]. Lastly, Takaba et al. reported on three patient cases restored using a hybrid structure of CAD-CAM porcelain crowns adhered to a CAD-CAM zirconia framework. The zirconia frameworks were cemented onto gold-platinum alloy or zirconia abutments, and then CAD-CAM porcelain crowns were cemented to the frameworks. These patients were followed for between 18 and 36 months and during this time no complications were noted [38].

2.3 Zirconia Prostheses

Another material choice for the fabrication of IFCDPs that has become popular in recent years is milled zirconia with or without veneering porcelain. Zirconia became popular due to its "good chemical properties, dimensional stability, high mechanical strength, toughness, and a Young's modulus similar to that of stainless steel alloy" [18] – properties that are far better than those of any other dental ceramic. Additionally, its white color and ability to transmit some light makes it a very useful dental material, particularly when in an esthetically important area of the oral cavity [18]. Thus, it is an ideal material to provide similar esthetics to those offered by acrylic or ceramic, but with dramatically improved resistance to wear and fracture.

The use of zirconia for IFCDPs was first described by Papaspyridakos and Lal in 2008. They point out that in addition to high flexural strength, zirconia also has excellent biological properties such as low corrosion potential, low thermal conductivity, and low bacterial adhesion. Equally important to zirconia's success is its ability to be incorporated into a digital workflow. Papaspyridakos and Lal suggested the use of zirconia for IFCDPs and described in detail their technique for the fabrication of a full-arch mandibular zirconia prosthesis with facial porcelain veneer [19]. Larsson et al. provided the first short-term follow-up of zirconia IFCDPs. Ten patients with edentulous mandibles were restored with cement-retained yttria-stabilized tetragonal zirconia polycrystal (Y-TZP) IFCDP frameworks with full porcelain

veneering. All but one prosthesis opposed fixed restorations. At the three-year follow-up, all prostheses were in function and all patients were fully satisfied with their treatment. Although none of the zirconia frameworks had fractured, 9 out of the 10 prostheses had sustained fractures of the veneering porcelain. Fortunately, the fractures were sufficiently minimal such that they could be managed through polishing alone [39]. Nonetheless, such prevalent complications are obviously undesirable. Three different techniques have evolved as a means of minimizing the possibility of these complications.

The first is the use of a very minimal porcelain veneer, strictly limited to non-functional surfaces. This not only serves to reduce the incidence of fracture, but also to reduce the amount of labor required and subsequently the cost. Venezia et al. provided a retrospective analysis of 26 zirconia IFCDPs with porcelain limited to the non-functional surfaces. With a mean follow-up time of 21 months, there was 100% prosthesis survival rate and an 83% success rate. Three of the prostheses had minor chipping of the veneering porcelain, which were addressed through intraoral adjustment and polishing [22].

The second technique is to eliminate the porcelain veneer entirely and to use monolithic zirconia. Rojas-Vizcaya described the delivery of maxillary and mandibular opposing monolithic Prettau® Y-TZP IFCPDs in a 52-year old patient. At 2 years of follow-up, there were no biologic or mechanical complications [20]. More recently a

study by Limmer et al. detailed a prospective trial of 17 patients with a mandibular monolithic zirconia IFCDP opposing a maxillary complete denture with a minimum of one year follow-up. The prostheses were found to have an 88% survival rate, as one was lost due to implant failure and another to framework fracture of the distal cantilever. Of the remaining patients, half experienced minor complications, most of which were chipping of the denture teeth in the opposing removable denture. Complications to the zirconia prostheses themselves were limited to fracture and loosening of the abutments and debonding of a cementable unit that was covering a screw access hole [23].

Unfortunately, this is not the only study to report catastrophic fracture of a zirconia IFCDP. Chang et al. reported another failure of a monolithic prosthesis. Their case report described the restoration of a healthy 79-year old male with 4 interforaminal implants and a screw-retained monolithic zirconia prosthesis opposing a tooth-supported maxillary overdenture. At the 18-month follow-up, all of the zirconia cylinders had been fractured and the contacting abutment surfaces had lost structural integrity. The damaged abutments had to be replaced and a new prosthesis had to be fabricated [25].

Although it is still subject to the risk of catastrophic zirconia fracture, a third technique has evolved as a hybrid of Maló's retrievable crown prosthesis and the monolithic zirconia prosthesis. In a clinical report Al-Mazedi et al. described the use of

maxillary and mandibular full arch frameworks with full anatomic molars milled into the framework, such that only the anteriors and premolars were designed as preparations for retrievable crowns. Pink porcelain was used for the gingival components and IPS e.max® Press restorations were used for the premolars and anteriors. After nearly a year of follow-up, no complications were noted beyond minimal occlusal adjustments [40].

2.4 The Subjective Experience of Implant-Fixed Complete Dental Prostheses

It has been established that the use of implant–supported overdentures improves quality of life (QoL) in the treatment of completely edentulous patients, as well as provides biological benefits such as the preservation of remaining alveolar bone [32, 41]. However, very few studies have examined improvements in QoL that result from metal-acrylic IFCDPs [26, 42, 43] and only one examines it in zirconia IFCDPs [23]. No study utilizes patient satisfaction or oral health-related quality of life (OHQoL) as a tool to compare these different implant-fixed treatment modalities.

Oral health-related QoL is the most commonly used means of assessing patient perception, and is considered a "more complete valuation of oral disease" than assessing "patient satisfaction."[23] The goal of QoL studies are to capture the impact of different types of dental prostheses in a comprehensive, multidimensional

assessment, and one of the most commonly used standardized instruments to accomplish this is the Oral Health Impact Profile (OHIP) [28]. OHIP is based on Locker's concept of oral health impacting the overall quality of life. OHIP-49 includes seven subscales to evaluate impairment: functional limitation, physical pain, psychological discomfort, disability (physical, psychological, and social disability), and handicap resulting from oral disease (Appendix A) [23]. Perhaps the most important aspect of OHIP is that it has been validated and demonstrates high internal reliability, as well as test-retest reliability [29].

Brennan et al. used a shortened version of OHIP (OHIP-14) as well as a patient satisfaction survey to compare OHQoL between 62 patients with either implant-supported overdentures or metal-acrylic IFCDPs. They found that patients with IFCDPs had significantly lower psychological discomfort and psychological disability than patients with overdentures. The authors also used a patient satisfaction survey which showed that while satisfaction was, on average, very high in both groups, patients with IFCDPs generally had higher overall satisfaction, as well as higher satisfaction with chewing and esthetics. The only areas that IFCDPs ranked lower than overdentures were cost, satisfaction with treating doctor, and ability to perform oral hygiene [26].

Similarly, Oh et al. used OHIP-14 as well as a patient satisfaction scale to compare OHQoL between metal-acrylic IFCDPs, removable implant-supported prostheses and complete dentures. Eighty-six patients were seen for face-to-face interviews. While OHQoL improved in all three groups after prosthetic treatment, OHQoL was not statistically different between IFCDPs and overdentures. The only statistically significant differences were between IFCDPs or overdentures when compared to complete dentures [43].

Only Limmer et al. assessed OHQoL with zirconia IFCDPs. They used OHIP-49. OHIP-49 scores can be tallied in several different ways. The severity score sums the ordinal responses across all items. As such, it ranges from 0 to 196 with a higher score denoting a lower QoL. If a patient reports that they experience a negative effect "fairly often" or "very often," this question is given a score of 3 or 4, respectively. The second scoring system, known as the extent score, sums only responses of a 3 or 4. Limmer et al. assessed both severity score and extent score at various time points throughout treatment and found that the mean severity score was 94.8 prior to initiating therapy and declined by an average of 76.8 after therapy [23].

Similarly to Limmer et al., we chose to assess OHQoL using OHIP-49. However, due to the broad nature of the questionnaire, we also wanted to give patients the opportunity to provide detailed feedback that was specific to IFCDPs. Thus, similarly

to Brennan et al. and Oh et al. we developed our own instrument to assess patient satisfaction. We formulated a scripted, open-ended patient interview with a single question in each of six categories to address the most common issues encountered by patients with IFCDPs: Overall, Esthetics, Occlusion, Phonetics, Hygiene, and TMJ (Appendix B).

3. METHODOLOGY

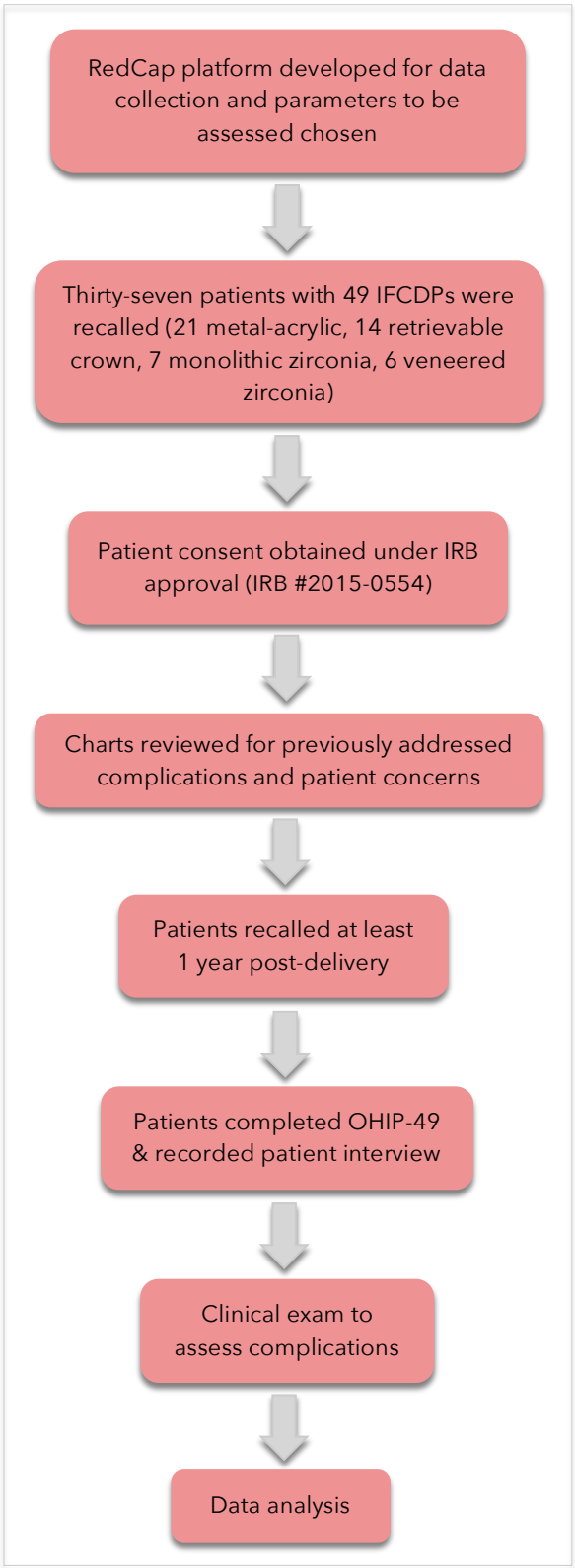
3.1 Study Design

The study protocol (#2015-0445) was reviewed and approved by the Institutional Review Board of the University of Illinois at Chicago. All patients who received a full-arch implant-supported prosthesis at the University of Illinois at Chicago Advanced Prosthodontics program no less than one year prior to the date of recall were then identified. The oldest retrievable crown prosthesis had been in service for 70 months and the oldest zirconia prosthesis had been in service for 41 months. Therefore, all metal-acrylic prostheses older than 70 months were excluded, as were all patients wearing a complete denture in one arch. Forty-five (45) patients with a total of 57 prostheses (22 metal-acrylic prostheses, 18 retrievable crown prostheses, 17 zirconia prostheses) were identified as meeting the study parameters.

3.2 Materials and Methods

Patients who met the inclusion criteria for the research study were contacted and recalled for an in person assessment at the University of Illinois at Chicago, College of Dentistry. A total of 37 patients with 49 prostheses, including 21 metal-acrylic prostheses, 14 retrievable crown prostheses, and 13 zirconia prostheses (7 monolithic zirconia and 6 zirconia with veneering porcelain) were recalled. All patients were seen by the same prosthodontic resident (VLH) for the clinical

Figure 1. Concept Map of Study Protocol



evaluation.

Patients began by completing the OHIP-49 questionnaire. They were instructed to answer the questions only as they pertained to their experiences since their final prosthesis had been delivered. It was acknowledged that patients likely had a long history of dental disease and treatment in order to have received an IFCDP, and the complexity of the therapy itself was discussed. Patients were then asked to ignore these previous experiences and to complete the survey relative to their final IFCDP only. If patients had opposing IFCDPs, they were asked to complete OHIP-49 for each prosthesis, as some patients noted varying experiences their with maxillary versus mandibular prosthesis, and other patients had prostheses of different materials opposing each other.

The patients were then interviewed following a written script of six questions; the interviews were recorded and later transcribed. The interviews usually lasted between 5 and 15 minutes. An intraoral exam was then performed and complications assessed. Prostheses were not removed and screw torque was not assessed unless the patient presented with prosthesis mobility. For statistical reasons the severity of a complication was not assessed and the number of times the same complication occurred for a given prosthesis was not recorded unless the provider felt that the complications were severe enough to merit remake of the entire prosthesis. In this case, the prosthesis was considered a "failure."

3.3 Statistical Analysis

Statistical software (SPSS v.20, Chicago, IL, USA) was used for descriptive and statistical analyses. Mean age (in years) and average length of service (in months) were determined for the overall sample and separately for each prosthetic group. Percentages of the whole were calculated for other demographic variables, including ratio of male to female patients and mandibular to maxillary prostheses, both for the overall sample and separately for each prosthetic group. A two-sided Fisher exact test was used to determine significance between varying complication rates among materials.

Average OHIP-49 scores and standard deviations were calculated for prosthetic material. Analysis of variance (ANOVA) was performed. Additionally, average values per question and standard deviations were calculated for each subsection within OHIP-49 and for every material group, and followed by an ANOVA test. For all statistical analyses in the study significance levels were set at $p<0.05$.

3.4 IRB Approval

Informed consent was obtained under a protocol (#2015-0554) reviewed and approved by the Institutional Review Board of the University of Illinois at Chicago for human participation in this study.

4. RESULTS

4.1 Demographic Results

In total, 37 patients with 49 prostheses met the inclusion criteria and presented to the clinic for dental examination. The study sample comprised 14 men and 23 women with an age range of 27 to 82 years. Twenty-four (24) maxillary prostheses and 25 mandibular prostheses were included. The average length of service for all prostheses was 22 months. The prostheses were supported by an average of 5.6 implants. The demographic information for each prosthetic type is listed in Table 1 below.

Table 1. Demographic information, separated by prosthetic material

	Total Number	Average Patient Age (yrs)	Average Length of Service (mo)	Male Patients (%)	Mandibular Prostheses (%)
Metal-Acrylic	22	67	21	27%	64%
Retrievable Crown	14	64	26	50%	43%
Zirconia					
Monolithic Zirconia	7	63	20	43%	29%
Porcelain Veneered Zirconia	6	62	17	33%	50%
TOTAL	**49**	**65 years**	**22 months**	**37%**	**49%**

4.2 Prosthetic Complication Results

Complications were assessed in four categories: Biologic, Prosthetic, Functional, and Complications to the Opposing Arch (Table 2). Results were analyzed using the two-sided Fisher exact test. The only statistically significant difference was loss of screw access plug.

Table 2. List of Complications Assessed

PROSTHETIC COMPLICATIONS	
BIOLOGIC	**FUNCTIONAL**
Radiographic Pathology	Unsatisfactory Esthetics
Bone Loss >1/3 Implant Length	Unsatisfactory phonetics
Implant Failure	
PROSTHETIC	**OPPOSING ARCH**
Replacement of Access Plug	Complaint of Pain
Screw Loosening	Marked Wear
Fractured Teeth	Fractured Dentition
Marked Anterior Wear	
Marked Posterior Wear	
Fractured Framework	
Debonded Framework	

Biologic Complications

No patients included in the study lost any implants or displayed radiographic pathology other than bone loss. Four prostheses were identified with bone loss around one or more implants greater than 1/3 the length of the implant. In none of

these cases did the bone loss result in prosthetic failure. One maxillary metal-acrylic IFCDP and three maxillary retrievable crown prostheses demonstrated radiographic bone loss greater than 1/3 the length of the implant (Table 3). The metal-acrylic prosthesis with bone loss was one of the prostheses with failure due to excessive tooth fracture, and was located around one of the distal-most implants. In one of the retrievable crown prostheses, the bone loss had been present prior to loading. In the other two, bone loss was localized to 1-3 implants and in one of the patients was possibly due to poor oral hygiene in the area of a large gingival ridge lap and lack of regular professional hygiene. Interestingly, no mandibular prostheses or zirconia prostheses showed radiographic evidence greater than 1/3 the length of the implant.

Table 3. Incidence of bone loss >1/3 implant length

BONE LOSS >1/3 IMPLANT LENGTH	
Material	**Percent of prostheses with complications %(n/N)**
Metal-Acrylic	5% (1/22)
Retrievable Crown	21% (3/14)
Zirconia	0%
Total	**8%**

Prosthetic Complications

No patients presented with complaints of lost access plugs for metal-acrylic or retrievable crown prostheses. However, 31% of the patients with zirconia prostheses

presented with a chief complaint of loss of a screw access plug or belief that the plug had been lost due to wear of the composite (Table 4). This resulted in sharp edges of the zirconia, which caused irritation and discomfort to the patient. Both monolithic and veneered zirconia had a significantly higher loss of screw access plugs than metal-acrylic or retrievable crown prostheses ($p=0.01$).

No patients presented with prosthesis mobility due to loose/lost screws. Not all screws could be accessed due to crown cementation over implant access holes in retrievable crown prostheses. Because of this, the decision was made not to assess screw loosening for any screws unless prosthesis mobility was noted. Therefore, none of the screws were assessed in any prosthesis and no complications with screw loosening were noted (Table 4).

Likewise, none of the prostheses included in this study had a framework fracture (Table 4). However, it is interesting to note that two of the patients included in the study with zirconia prostheses had these zirconia prostheses fabricated due to fracture of a prior metal-acrylic titanium framework. Because their previous metal-acrylic prostheses had been fabricated more than 70 months prior, those previous prostheses could not be included in this study.

Only two prostheses demonstrated marked anterior wear, one metal-acrylic and one zirconia prosthesis with veneering porcelain. Both were mandibular prostheses and both were prostheses that were considered “failures“ due to an

excessive number of tooth fractures. While anterior wear was relatively uncommon, posterior wear was the most commonly noted overall complication. Ten (10) out of 22 metal-acrylic prostheses and 3 of 14 retrievable crown prostheses demonstrated posterior wear, defined for the purposes of this study as obliteration of the central groove anatomy of at least one tooth. Additionally, three zirconia prostheses were noted to have wear of posterior teeth, two with veneering porcelain and one monolithic zirconia prosthesis. It should be noted, however, that both of the worn zirconia prostheses with veneering porcelain were opposing each other in the same patient, and were deemed as "failures" due to large numbers of fractured teeth, likely due to parafunctional habits and significant occlusal forces, coupled with the patient's refusal to wear an occlusal guard at night. The monolithic zirconia prosthesis was categorized as heaving wear due to obliteration of occlusal anatomy of a molar and concurrent wear of the opposing restoration. However, the possibility that this wear faceting was iatrogenic cannot be ruled out.

The second most commonly seen complication, and the most common complication for retrievable crown prostheses was fractured teeth. This was noted in 18% of meta-acrylic prostheses, 43% of retrievable crown prostheses, and 43% of zirconia prostheses with veneering porcelain. No fractures were noted of the monolithic zirconia prostheses.

Table 4. Prosthetic complications, distributed according to material

Prosthetic Complications (Percentage of Prostheses Affected)	Replacement of Access Plug % (n/N)	Screw Loosening % (n/N)	Fractured Framework % (n/N)	Marked Anterior Wear % (n/N)	Marked Posterior Wear % (n/N)	Fractured Teeth % (n/N)	Debond of Gingival Material or Crowns % (n/N)
Metal-Acrylic	0	0	0	5 (1/22)	45* (10/22)	18 (4/22)	0
Retrievable Crown	0	0	0	0	21 (3/14)	43§ (6/14)	29 (4/14)
Zirconia							
Monolithic Zirconia	14 (1/7)	0	0	0	14 (1/7)	0	0
Porcelain Veneered Zirconia	50 (3/6)	0	0	17 (1/6)	33 (2/6)	50 (3/6)	0
TOTAL	**8%**	**0%**	**0%**	**5%**	**39%**	**27%**	**8%**

* Most common complication with metal-acrylic prostheses

§ Most common complication with retrievable crown prostheses

The last prosthetic complication assessed was debonding: 1. of artificial gingival material, 2. of crowns from a retrievable crown prosthesis, and 3. of the zirconia framework from the metal inserts connecting the prosthesis to the implants. No debonding or fractures of acrylic gingival were noted in metal-acrylic prostheses and no zirconia frameworks exhibited debonding from their metal inserts. Four (4) of the 14 retrievable crowns prostheses were included: 3 had lost portions of the composite gingiva (Figure 2) and two had crowns that debonded from the frameworks (one with crowns that had been cemented with a temporary cement and the other with permanent cement, Figure 3). It should be noted that one zirconia IFCDP did debond from the metal inserts, as was noted through chart review. However, this patient was not able to be recalled for the study, and therefore, could not be included.

Figure 2. Area of debonded composite gingiva on retrievable crown IFCDP

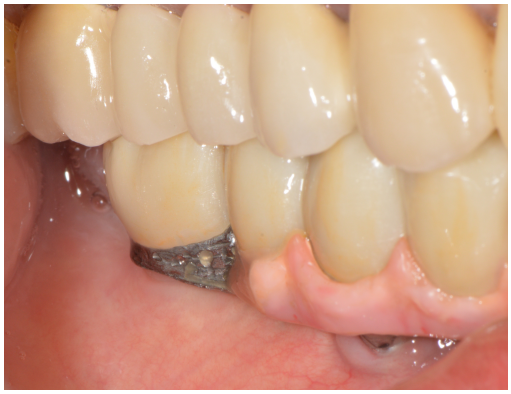
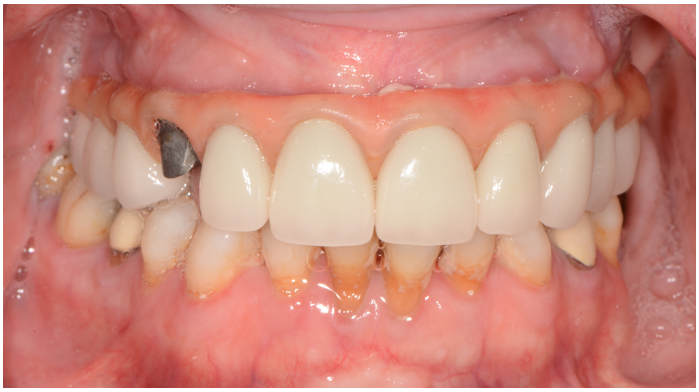


Figure 3. Debonded retrievable crown after 70 months in function



Functional Complications

Due to concerns about the potentially unesthetic nature of monolithic zirconia, we wanted to provide a quantitative analysis of patients' subjective concerns. To accomplish this we assessed provider and patient concerns regarding an esthetic or phonetic deficiency (Table 5). Two patients with single metal-acrylic IFCDPs did not approve of the esthetics of their prostheses, both of which cited that they felt their provider had not listened or been able to achieve the esthetics they desired. One patient with a zirconia prosthesis with veneering porcelain was not happy with the esthetics of her prosthesis. Interestingly, this patient had an opposing metal-acrylic IFCDP, which she preferred, and she was unhappy that the teeth did not appear as separate in the zirconia prosthesis, even with veneering porcelain, as they did with the metal-acrylic prosthesis. Perhaps surprising is that all patients with monolithic zirconia prostheses rated themselves as "very satisfied" with the esthetics of their prostheses.

One patient with a metal–acrylic prosthesis and two patients with retrievable crown prostheses felt that their speech was affected and did not resolve to their satisfaction over time.

Table 5. Functional concerns, distributed according to material

Functional Complications (Percentage of Prostheses Affected)	Concerns with esthetics % (n/N)	Concerns with phonetics % (n/N)
Metal-Acrylic	9 (2/22)	5 (1/22)
Retrievable Crown	0	14 (2/14)
Zirconia		
Monolithic Zirconia	0	0
Porcelain Veneered Zirconia	17 (1/6)	0
TOTAL	**6%**	**6%**

Complications to the Opposing Arch

Four (4) out of 22 metal-acrylic prostheses did cause wear to the opposing arch. In all of these cases, the opposing arch was either a metal-acrylic IFCDP or a implant-supported overdenture (Table 6). It should be noted that two of these prostheses were in the same patient, and were deemed to have "failed." Three retrievable crown prostheses resulted in wear to the opposing arch, two of which were opposing other IFCDPs. Five (5) of 13 zirconia prostheses resulted in wear to the opposing arch. Note that while the data indicated that the wearing of the opposing dentition with metal acrylic and cementable crowns occurred with nearly identical relative frequencies (18% and 21% respectively), this same complication occurred for zirconia prostheses with and without porcelain veneer in 29% and 50% of prostheses, respectively (p=0.155).

Table 6. Complications occurring in opposing arch, distributed according to material

Complications to Opposing Arch (Percentage of Prostheses Affected)	Wear of Opposing % (n/N)	Fractures in Opposing % (n/N)
Metal-Acrylic	18 (4/22)	18 (4/22)
Retrievable Crown	21 (3/14)	36 (5/14)
Zirconia		
Monolithic Zirconia	29† (2/7)	14 (1/7)
Porcelain Veneered Zirconia	50 (3/6)	66‡ (4/6)
TOTAL	**25%**	**29%**

† Most common complication with monolithic zirconia prostheses

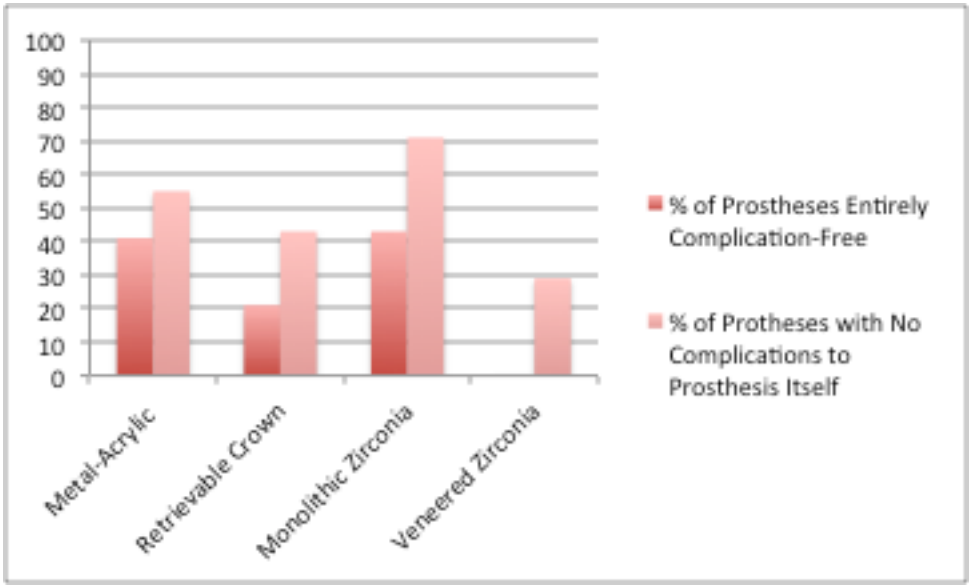
‡ Most common complication for zirconia prostheses with veneering porcelain

Tooth fracture in the opposing arch was equally common (Table 6). Fractures of teeth in the opposing arch were seen with 4 of 22 metal-acrylic prostheses. Similar to the situation with wear, they were all opposing either metal-acrylic IFCDPs or metal-acrylic implant-supported overdentures. Additionally, three of the prostheses were the same as the ones mentioned above which resulted in wear, and two of which were deemed failed treatment. Five (5) of 14 retrievable crown prostheses resulted in chipping or fracturing of restorations in the opposing arch. One monolithic mandibular prosthesis resulted in a chip of veneering porcelain on a canine in the opposing arch, and four of the veneered prostheses resulted in

chipping or fracturing of restorations in the opposing arch, three of which were opposing another zirconia IFCDP with veneering porcelain.

Risk of complications can also be assessed by determining the percentage of prostheses free from complications at the time of recall. Being "complication-free" was defined in two different ways: 1. as the percentage of prostheses with no complications at all, and 2. as the percentage of prostheses with no complications occurring within the prosthetic material, even if there were biologic or functional complications or complications to the opposing arch.

Figure 4. Percentage of Prostheses Free From Complications

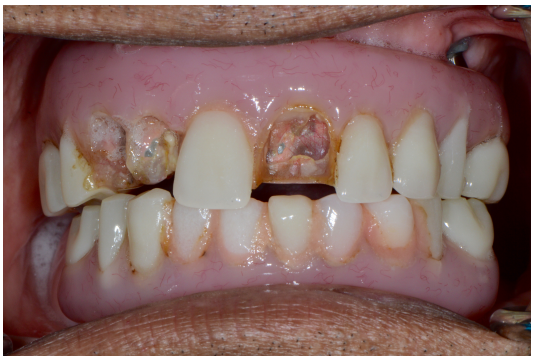


For metal-acrylic prostheses, 9 of 22 prostheses were entirely complication free after 21 months, and 12 of 22 prostheses had no complications occurring to the prosthesis itself (Figure 4). For retrievable crown prostheses, only 3 of 14 prostheses

were entirely complication free, and 6 of 14 had no complications to the prosthesis itself. For monolithic zirconia prostheses, 3 of 7 had no complications at all and 5 of 7 had no complications with prosthesis itself. For veneered zirconia the results were 0 of 7 and 2 of 7, respectively (Figure 4).

4.3 Prosthetic Failure Discussion

Figure 5. Failed metal-acrylic prostheses



Prosthetic failure was defined as a prosthesis with complications severe enough to demand remake of the prosthesis. Six prostheses in three patients met this description; two metal-acrylic prostheses opposing each other (Figure 5), two zirconia prostheses with veneering porcelain opposing each other (Figure 6), and two retrievable crown prostheses opposing each other (Figure 7). All of the failures were due to excessive chipping and fracturing of the prosthetic teeth. In two cases, the patients reported that they were wearing their occlusal guards both day and night, but restorations were still breaking when they took their occlusal guards out to eat. No monolithic zirconia prostheses failed for any reason.

Figure 6. Failed retrievable crown prostheses

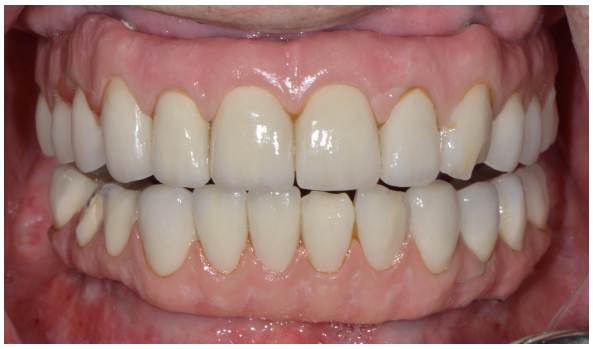
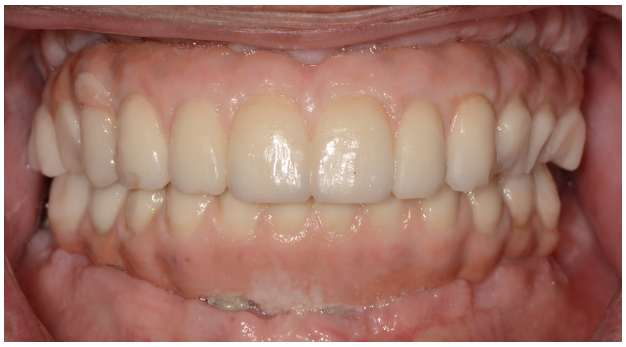


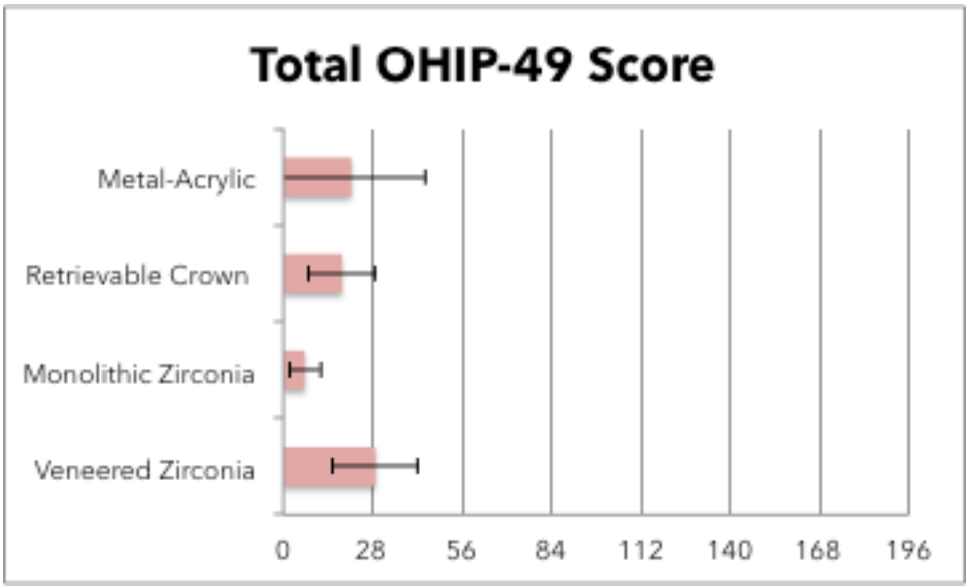
Figure 7. Failed zirconia prostheses with veneering porcelain



4.4 Oral Health Related Quality of Life

Severity scores were averaged for the OHIP-49 survey for each prosthetic material. Patients can respond to each of the 49 survey questions regarding the incidence of a given complication with an answer from "never"=0 to "very often"=4. Thus, the total score can range from 0 to 196; the closer a score is to 0, the better the patient's OHQoL. Patients with zirconia prostheses with veneering porcelain reported the most complications that had a negative impact on their OHQoL, with an average total score of 29 (Figure 6). Patients with monolithic zirconia prostheses reported the fewest complications with an average score of 7 (Figure 8). However, it should be noted that all of these values are very low, indicating all patients have an excellent OHQoL. Additionally, the differences were not statistically significant (p=0.16).

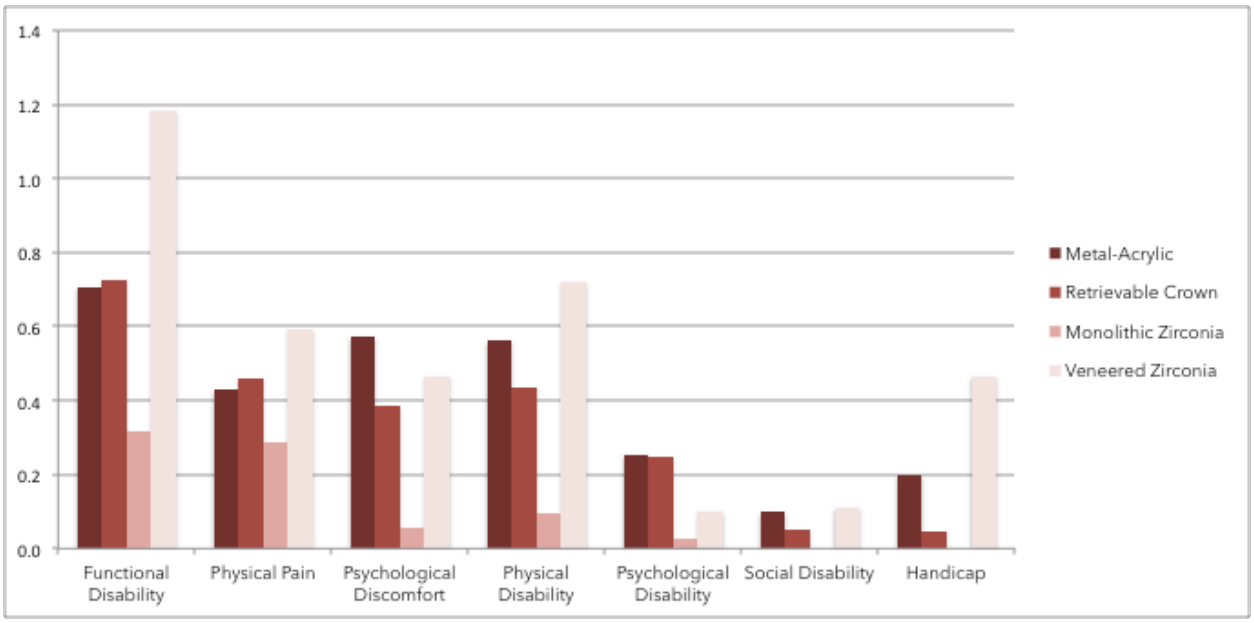
Figure 8. Average OHIP-49 scores



Next, the seven different categories for the OHIP-49 questionnaire: functional limitation, physical pain, psychological discomfort, disability (physical, psychological, and social disability), and handicap resulting from oral disease were analyzed separately. Each question asks about the prevalence of a disturbance in the patient's OHQoL. The average scores were less than 1 point (1="hardly ever") per question in every category and for every prosthetic material, with the exception of patients with veneered zirconia prostheses and only in the functional limitation category. In this category the average score per question was 1.18 (Figure 9). Across all prosthetic groups, patients ranked functional limitation as the category which caused the greatest disturbance to their OHQoL and social disability as the least important. The trend in each of the seven OHIP-49 categories was that patients with monolithic

zirconia prostheses had the lowest scores and therefore, the fewest complaints, although the differences were not statistically significant.

Figure 9. Average response per question



4.5 Patient Interviews

Due to the general nature of the OHIP questionnaire, we also wanted to provide patients the opportunity to discuss their experiences in more detail. Therefore, each patient was asked to participate in a recorded interview of six open-ended questions. The topics were chosen based on the most common patient complaints with IFCDPs [16, 43, 44] (Appendix B). Interviews typically lasted 5-15 minutes. The patients were not queued in any direction in their responses.

The interviews were then transcribed. In order to provide a meaningful summary, the responses were minimally condensed. However, attempts were made to compile responses around direct quotes to the greatest extent possible.

Table 7. Patients' responses to open-ended survey questions, by percentage of total respondents (n=37).

Question	Percentage
Question 1: In general, how satisfied have you been with your new prosthesis?	
I have been extremely happy (5 out of 5).	73%
I have been reasonably happy (4 out of 5).	14%
I have been only somewhat happy (3 out of 5).	14%
There is more bulk to the prosthesis than I expected.	14%
I am bothered by the space and/or margin between my prosthesis and my gums.	8%
Question 2: What do you think of the esthetics of your prosthesis?	
I think they look great.	89%
I wish I could change some aspect (whiter, longer, etc.)	19%
I don't think they look very natural.	8%
I think they look very natural	5%
I think they look even better than my natural teeth.	5%
Question 3: Please tell me about your bite and chewing function.	
Chewing is fine; I have no problems.	84%
I try to avoid certain foods (popcorn, ice, nuts) because I'm concerned about my prosthesis breaking.	38%
I eat anything I want.	32%
There are certain foods I avoid because I find they get stuck under the prosthesis.	13%
Small foods (such as rice) are challenging to chew.	11%
Chewing has never felt natural.	8%
I had to relearn how to eat.	5%
I wish there were more teeth in my prosthesis.	5%

Question 4: Please tell me about speaking with your new prosthesis.

I have no problems speaking.	46%
There was an adjustment period, but I have no problems with my speech now.	41%
My speech was never affected; I had no adjustment period.	19%
I still have problems speaking certain words.	19%
My teeth were so messed up before that I think it is even better now.	14%
I still need to be conscientious when speaking in order to pronounce certain words correctly.	5%

Question 5: Please tell me about cleaning your prosthesis.

I have had good success with my Waterpik.	59%
I do not find keeping it clean to be problematic or onerous.	54%
I spend at least 15-20 minutes daily cleaning my prosthesis.	16%
It does not take me more than 5 or 10 minutes to clean	14%
Keeping my prosthesis clean is a challenge.	14%
I had to learn new techniques in order to clean properly.	14%

Question 6: Please tell me about any issues related to your jaw joint or any grinding habits.

I have noticed no changes and have no problems.	84%
I wear my occlusal guard every night.	32%
I do not wear an occlusal guard.	22%
I have an occlusal guard, but do not wear it regularly.	16%
I have occasional soreness in my jaw joint.	8%
I have developed painless clicking and popping in my joint.	3%

5. DISCUSSION

5.1 Prosthetic Complication Discussion

Within the limitations of the study, the hypothesis that metal-acrylic prostheses would have the most complications, but the fewest prosthetic failures, could not be rejected. However, the trends in the data indicate that the highest percentage of monolithic zirconia prostheses were free of complications at the time of recall, followed closely by metal-acrylic prostheses. Conversely, no zirconia prostheses with veneering porcelain were found to be entirely free of complications.

For metal-acrylic prostheses, the most common complication observed was posterior tooth wear. Forty-five (45) percent of prostheses were classified as having posterior wear, defined as distortion of the occlusal anatomy to the extent that central groove anatomy was altered, after 21 months in function. This is similar to the data presented by Carlson and Carlsson who noted that 60% of prostheses had some problem with the acrylic resin matrix, with many of the prostheses having been in service for only 2-3 years [32]. The finding is also similar to that of Purcell et al. who noted that tooth replacement due to wear was required in 26 of 49 prostheses after 5 years [16].

Another common complication, tooth fracture, was noted in 18% of metal-acrylic prostheses. This is similar to the finding of Gothberg et al. who noted that fractures of the acrylic resin teeth were the most common complications with 23% of

patients having returned to the clinic with the chief complaint of fractured acrylic resin matrix. These numbers are also correlated by Purcell et al. who found that 9 teeth broke in 46 prostheses within a two-year time frame [16].

The most common complication observed in retrievable porcelain crown prostheses is chipping and/or fracturing of at least one restoration. This occurred in 43% of prostheses included in this study. This is similar to the results of Maló et al. who found that mechanical complications occurred in 55% of prostheses restored with Allceram® crowns and in 27% of prostheses restored with PFZ crowns, most of which were chipping and fracturing of the crowns [17]. However, unlike the Maló study, due to the small sample size, this study did not attempt to record whether the patient was aware of this complication or whether they presented with it as the chief complaint. Similarly, no distinction was made between fractures which could be repaired through polishing alone or if replacement of the restoration was necessary.

Another complication that was noted at a relatively high percentage in this study (29%), which has not been discussed much in other studies, is debonding of the composite resin gingiva or debonding of the crowns from the bar. Similarly to chipping of crowns, some patients were not aware gingival debonding had occurred, while others presented with it as their chief complaint. Patients seemed more likely to be aware of gingival debonding when it was on the lingual aspect and caused lingual irritation. The chart reviews revealed that once the acrylic gingiva fractured, attempts

to repair the gingival intraorally were generally unsuccessful long-term and patients continued to present with the same complaint until it was decided that area would be polished and metal substructure left exposed.

The most common complication noted with monolithic zirconia prostheses was wear of the opposing arch (33%). The most common complication noted for zirconia prostheses with veneering porcelain was fractures in the opposing arch (66%). However, fractures of veneering porcelain in the prostheses themselves (43%), as well as loss of the screw access plug (43%) were also common complications.

Despite the high number of complications in retrievable crown and veneered zirconia prostheses, even when compared to metal-acrylic prostheses, it is important to keep in mind the limitations of this study. One of the most significant is that material selection is not randomized. Thus, if a patient has certain characteristics that a provider might assume put the patient at risk of complications (ie. younger age, male gender, low Frankfort mandibular plane angle), they might steer the patient away from selecting a metal acrylic prostheses. The demographic information suggests that this is in fact the case. Only 27% of patients wearing metal-acrylic prostheses, while 43% of patients with monolithic zirconia prostheses were male. Additionally, if a provider notices that a patient is fracturing a large number of acrylic teeth during the provisional phase, a more durable material can be selected for the final prosthesis.

Therefore, metal-acrylic prostheses could appear to have fewer complications than they would have in a randomized population. Although this lack of randomization and the influence of provider bias may invalidate certain comparisons of complications between prosthetic materials, it could be argued that the data indicates that in the right patient population metal-acrylic prostheses can be a very good treatment modality.

Another complicating factor is that the prostheses included in this study were delivered by a large number of different providers and fabricated by multiple laboratories. This may not have such a dramatic effect on the complications with metal-acrylic or monolithic zirconia prostheses, as treatment planning and fabrication techniques for theses prosthetic styles are relatively well-defined. However, it likely affected the complications observed for retrievable crown prostheses and veneered zirconia prostheses much more dramatically.

Within this study, some of the restorations on the retrievable crown prostheses were PFM single units, while one case had three-unit fixed partial dentures cemented in the posterior with a six unit fixed partial denture in the anterior. Two prostheses had all-ceramic restorations. Some of the restorations had been cemented with temporary cement and others with permanent cement. All of these factors can differentially influence the complications observed.

In the case of veneered zirconia, three different labs were used to fabricate the six prostheses included. Furthermore, for each of these six prostheses, the provider did not request to see the zirconia cutback prior to the lab stacking the porcelain. Thus, it is impossible for the provider to determine whether there was appropriately designed support for the porcelain veneer. Recently, the importance of a proper slow cooling cycle has been established, as well as a trend to provide only a minimal veneer of feldspathic ceramic and to ensure that it is completely out of functional occlusion [12, 45]. Within these guidelines, the incidence of complications with veneered zirconia IFCDPs has been shown to be quite low [12, 45]. However, as the amount of porcelain veneer in these cases was not and cannot be assessed, it should be noted that the large number of complications observed in this study cannot be extrapolated to all techniques for veneering zirconia.

A third limitation of the study is that it was difficult, if not impossible, to distinguish certain complications observed from adjustments that were made at the time of delivery. For example, in determining wear of both the prosthesis of interest and wear of the opposing arch, there were no specific factors that could be used to rule out the possibility that the "wear" noted was not iatrogenic in nature and due to adjustments by the treating prosthodontic resident.

5.2 Prosthetic Failure Discussion

As was mentioned earlier, for statistical reasons it was decided to assess the presence of complications categorically, thus minimizing the ability to report the severity of a given complication. For example, whether there was a small chip of veneering porcelain on the distobuccal cusp of a molar or large fractures of all six maxillary incisors, tooth fracture was simply marked as "1=present". However, severe complications, such as a fractured framework which would require the prosthesis to be remade must be differentiated from minor complications.

Therefore, prosthetic failure was defined as a prosthesis with complications severe enough to demand remake of the prosthesis. However, despite attempts at a strict definition, the exact qualifications are not entirely obvious. For metal-acrylic IFCDPs, does stripping the bar and replacing all of the teeth qualify as a "failure"? What if the reason for replacement is due to wear, which can be considered expected maintenance? For retrievable crown prostheses, does having to replace all of the restorations on a single arch, but being able to reuse the framework qualify? What if only 8 of the 12 restorations needed to be replaced on the bar? From the patient's perspective, this may still be considered a failure when the prosthesis is less than 20 months old. Thus, the criteria and definition of "failure" is subjective from the provider's, as well as the patient's, perspective. Furthermore, it should also be noted that although prosthetic replacement was offered at cost of lab fees only to the three

patients with prosthetic "failures," only one patient accepted the offer, while the other two stated that the fractures did not bother them enough to be worth replacement.

5.3 OHIP-49 Discussion

Our hypothesis that patients with retrievable crown and milled zirconia prostheses will have the highest OHQoL could not be proven. In fact, the trends of the overall OHIP-49 questionnaire showed that patients with monolithic zirconia prostheses had the fewest negative factors influencing their OHQoL, although the results were not statistically significant ($p=0.16$). However, there could be selection bias involved. The patients with the lowest esthetic expectations were likely the ones chosen to receive monolithic zirconia prostheses and thus it is possible that they also had lower expectations in general and therefore, were more easily satisfied overall.

It could be argued that the most important aspect of the overall OHIP-49 scores was that the average patient had a very high OHQoL, regardless of the prosthetic material selected. Average OHIP-49 scores among prosthetic designs ranged from 7 to 29, which is consistent with the literature. Limmer et al. is the only study to publish OHIP-49 results with IFCDPs; they found that 12 months after enrollment the average score was 18 after having completed therapy with mandibular monolithic zirconia IFCDPs [23]. Analysis of the individual subsections of the OHIP-59 questionnaire again demonstrated no statistically significant differences

between prosthetic designs. However, the trend observed was that functional limitation was the most important factor for all groups, while social disability played the least important role.

5.4 Patient Interview Discussion

Because responses to the patient interview questions were open-ended, responses could go in any number of directions. Therefore, in order to summarize effectively, it was decided to pool responses across all material types. Responses to question 1 regarding patients' overall satisfaction revealed that most patients were very (14%) to extremely satisfied (73%) with their therapy. This is similar to the results of Oh et al. who found that 100% of patients with metal-acrylic IFCDPs were either neutral or satisfied with their prosthesis [43]. It is similar, although slightly higher, than the results of Martín-Ares et al. who found that 46% of patients with metal-acrylic IFCDPs were extremely satisfied, while another 28% were moderately satisfied [44]. However, some patients did mention difficulty adjusting to the material bulk (14%) and frustration with food entrapment in the space between the prosthesis and the natural gingiva which went beyond a hygiene issue (8%). A similar concern was addressed by Oh et al. who found that 13.8% of patients were dissatisfied with the way in which foreign substances got caught under their prosthesis [43].

Most (89%, Table 7) patients thought their prostheses "looked great." This is similar to the findings of Oh et al. who noted that 100% of patients were satisfied with the esthetics of their prosthesis, their ability to smile naturally, and their comfort during conversation [43]. However, in our study approximately a fifth of patients reported they would have preferred for certain esthetics to have been different. These attributes ranged from wanting the teeth to have been "even whiter" to wishing the teeth could be longer, further anterior, etc. In some of the cases where the patients wished their teeth could have been in a different position, they acknowledged that this was a conversation that they had previously with their provider. It had been explained to them that for various reasons doing so would have put them at risk for complications. Thus, the decision was mutually made between the patient and the provider to place the teeth in a slightly different position. In these cases, the patients seemed more likely to be satisfied, while in other cases the patients complained that they felt their desires were not acknowledged or that they were being "rushed through" the process.

Most patients (84%, Table 7) felt that chewing with their prosthesis was satisfactory. Interestingly, a third or patients felt that they could eat anything they wanted (34%), which was not mutually exclusive with the group of patients (38%) who actively tried to avoid foods they perceived as hard (ice, popcorn, nuts) and more likely to damaged their prostheses. The patients who commented that they had

trouble eating certain foods were relatively few (11%). The foods that they mentioned avoiding were foods small in size, such as rice and certain grains. These patients stated that the difficulty lay both in mastication and in getting the food stuck under and around the prostheses.

Oh et al. found that 100% of patients reported no discomfort on chewing and 95.9% reported no problems eating hard foods [43]. Martín-Ares et al. examined several different aspects of chewing function. On a scale on 0 to 4, where 0=never and 4=very often they found that in a group of 50 patients with metal-acrylic IFCDPs the patients generally reported almost no dietary problems (0.14) or discomfort eating certain foods (0.64). The authors did note occasional disruption of meals with an average score of 1.12, where 1=hardly even and 2=occasional [44].

In terms of the effect of the prostheses on speech, there was a wide variety of responses ranging from “I have no problems” to “I had problems initially, but am fine now” to “I still have to focus on speaking clearly”. Only a small percentage of patients (5%, Table 7) felt that they were still not able to speak clearly, while some (14%) said that their speech had actually improved compared to prior to initiating therapy. Oh et al. reported 100% satisfaction with “comfort during pronunciation” [43]. Martín-Ares et al. reported that patients hardly ever had difficulty pronouncing certain words (0.54), and had significantly fewer problems with pronunciation than patients with complete dentures (2.24) or overdentures (1.14) [44].

Regarding hygiene of the prostheses, many patients (59%, Table 7) commented that a Waterpik helped significantly in keeping their prostheses clean. Many patients (54%) commented that they did not feel that cleaning their prosthesis was particularly challenging or onerous, although some (16%) did mention that this took approximately 15-20 minutes daily. According to Martín-Ares et al. difficulty cleaning the prosthesis was the patient's biggest complaint with IFCDPs. Even still, they noted these concerns arising only infrequently to occasionally [44].

The last question addressed patient concerns with temporomandibular disorders or parafunctional habits. Most patients (84%, Table 7) stated that they had no problems. Some patients who were aware of parafunctional habits mentioned that they wore an occlusal guard nightly (34%), while others stated that they had an occlusal guard but did not wear it regularly (16%) and one stated it was "unwearable". Only a small percentage of patients stated that they had occasional soreness (8%).

6. CONCLUSIONS

Given proper patient selection metal-acrylic, retrievable crown, and zirconia implant-fixed complete dental prostheses can all provide an excellent solution for the edentulous patient. However, all of these treatment modalities have complications associated with them, which patients need to be informed about. In this study, the percentage of prostheses with complications was found to be relatively high, and the type of complication varied based on the material selected. Therefore, it is important to discuss these limitations and complications with patients to assist them in making an informed decision in regards to their treatment of choice while also instilling a realistic understanding of their treatment expectations. However, regardless of the material ultimately chosen, the providers can be confident that most patients will have a high oral health-related quality of life.

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APPENDICES

APPENDIX A. OHIP-49 Questions

Functional limitation questions

1. Have you had difficulty chewing any foods because of problems with your teeth, mouth, or dentures?
2. Have you had trouble pronouncing any words because of problems with your teeth, mouth, or dentures?
3. Have you notice a tooth which doesn't look right?
4. Have you felt that your appearance has been affected because of problems with your teeth, mouth, or dentures?
5. Have you felt that your breath has been stale because of problems with your teeth, mouth, or dentures?
6. Have you felt that your sense of taste has worsened because of problems with your teeth, mouth, or dentures?
7. Have you had food catching in your teeth or dentures?
8. Have you felt that your digestion has worsened because of problems with your teeth, mouth, or dentures?
9. Have you felt that your dentures have not been fitting properly?

Physical pain

10. Have you had painful aching in your mouth?
11. Have you had a sore jaw?
12. Have you had headaches between of problems with your teeth, mouth or dentures?
13. Have you had sensitive teeth, for example, due to hot or cold foods or drinks?
14. Have you had a toothache?
15. Have you had painful gums?
16. Have you found it uncomfortable to eat any food because of problems with your teeth, mouth, or dentures?
17. Have you had sore spots in your mouth?
18. Have you had uncomfortable dentures?

Psychological discomfort

19. Have you been worried by dental problems?
20. Have you been self conscious because of your teeth, mouth, or dentures?
21. Have dental problems made you miserable?
22. Have you felt uncomfortable about the appearance of your teeth, mouth, or dentures?

Physical disability

24. Has you speech been unclear because of problems with your teeth, mouth, or dentures?
25. Have people misunderstood some of your words because of problems with your teeth, mouth, or dentures?
26. Have you felt that there has been less flavor in your food because of problems with your teeth, mouth, or dentures?
27. Have you been unable to brush your teeth properly because of problems with your teeth, mouth,

or dentures?

28. Have you had to avoid eating some foods because of problems with your teeth, mouth, or dentures?
29. Has your diet been unsatisfactory because of problems with your teeth, mouth, or dentures?
30. Have you been unable to eat because of problems with your teeth, mouth, or dentures?
31. Have you avoided smiling because of problems with your teeth, mouth, or dentures?
32. Have you had to interrupt meals because of problems with your teeth, mouth, or dentures?

Psychological disability

33. Has your sleep been interrupted because of problems with your teeth, mouth, or dentures?
34. Have you been upset because of problems with your teeth, mouth, or dentures?
35. Have you found it difficult to relax because of problems with your teeth, mouth, or dentures?
36. Have you felt depressed because of problems with your teeth, mouth, or dentures?
37. Has your concentration been affected because of problems with your teeth, mouth, or dentures?
38. Have you been a bit embarrassed because of problems with your teeth, mouth, or dentures?

Social disability

39. Have you avoided going out because of problems with your teeth, mouth, or dentures?
40. Have you been less tolerant of your spouse or family because of problems with your teeth, mouth, or dentures?
41. Have you had trouble getting on with other people because of problems with your teeth, mouth, or dentures?
42. Have you been a bit irritable with other people because of problems with your teeth, mouth, or dentures?
43. Have you had difficulty doing your usual jobs because of problems with your teeth, mouth, or dentures?

Handicap

44. Have you felt that your general health has worsened because of problems with your teeth, mouth, or dentures?
45. Have you suffered any financial loss because of problems with your teeth, mouth, or dentures?
46. Have you been unable to enjoy other people's company as much because of problems with your teeth, mouth, or dentures?
47. Have you felt that life in general was less satisfying because of problems with your teeth, mouth, or dentures?
48. Have you been totally unable to function because of problems with your teeth, mouth, or dentures?
49. Have you been unable to work to your full capacity because of problems with your teeth, mouth, or dentures?

APPENDIX B. Interview Questions.

Overall

How happy are you generally with your prosthesis? Why would you say you are (happy/unhappy/somewhat happy, etc)?

Esthetics

Please tell me what you think about the esthetics of your prosthesis.

Occlusion

Please tell me about your bite and chewing function. Can you give me any specific examples?

Phonetics

Please tell me about speaking with your prosthesis.

Hygiene

Please tell me about any difficulties cleaning your prosthesis. Can you give me any specific examples?

TMJ

Please tell me about any issues related to your jaw joint.

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