Comparison of Crown Production over the Years in the Graduate Prosthodontics Clinic at the University of Pittsburgh School of Dental Medicine

by

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Abstract

Background: Dental materials have developed over the years. Dentists choose the crown materials for their patients depending on the amount of tooth structure available, esthetics, location of the tooth, and occlusion. Due to the advancement of dental materials, we hypothesize there is a shift in material of choice for crowns from metallic to more aesthetic options. Hence, metal free restorations are more likely to be used nowadays than metal restorations.

Objectives: The objective of this study was to evaluate the crown production in the Graduate Prosthodontics Clinic at the University Of Pittsburgh School Of Dental Medicine over the last few years to determine if there is a difference in material of choice. The null hypothesis of this study was that there is no difference in crown production over recent years.

Search methods: Data were collected from the electronic health records (Axium) from two residents with high productivity to decrease inter-professional variability. One resident worked from 2016 to 2018, and the other one worked from 2014 to 2016. Codes related to crowns included: all metal (D2790, D2792, D6210), porcelain-fused-to-metal (D2750, D2752, D6240, D6242, D6750, D6752), and all ceramic (D2740, D6245, D6740).

Results: The present analysis provides useful new data that there is an increase in zirconia crown production in the Graduate Prosthodontics Clinic at the University Of Pittsburgh School Of Dental Medicine in recent years.

Conclusion: There is a trend toward using all ceramic crowns and FPDs in the graduate prosthodontic clinic at the University of Pittsburgh School of dental medicine.

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1.0 Introduction

The goal of dental restoration is to reintegrate function and esthetics for patients with as little damage as possible to dentition and sustain long-term durability and strength. With new technologies in dentistry and ongoing advancement in materials used, excellent results are being achieved. The choice of materials and systems depend on many factors and the individual need and desires of the patient. As a result of continuous research, more materials are used in dentistry than almost any other industry. Some of the materials that dentists use are plastics, metals, ceramics, and more. In today's world, aesthetic demands have increased, which motivated the dental industry to increase aesthetic and mechanical properties of restorative materials. Fixed prosthodontic treatments, which include crowns, fixed partial denture, and complete arch prostheses, involve the use of several types of materials to protect and replace missing tooth structure.

Full metal crowns and porcelain-fused- to metal crowns have been commonly used for several years, and extensive studies of their use have been conducted. The studies have shown a 94% success rate over ten years. Chipping of the veneer or fracture of the metal frame is uncommon (26). The major disadvantage of porcelain-fused metal crown is they result in low esthetic qualities (26). With extensive study and use of ceramic-metal crowns, the attitude has developed with some scholars that to further advance dental porcelains, new composition materials and techniques will be required (7). Unsurprisingly, new materials and methods have been developed that offer new and improved options for dental restorations. For example, metal free restorations have become available, which allow practitioners to produce more natural restorations that meet patient's aesthetic expectations. In addition, with increasing costs of noble metals, all-

ceramic crowns are becoming more popular. By 2008, it was predicted that over half of all crowns would be made from all-ceramic materials (4). Indeed, all-ceramic restoration materials have become an established alternative to all-metallic or ceramic-metal materials (27). Nevertheless, it took some time before all-ceramic materials became a common choice. This is due to the issue of low mechanical stability, and as a result, all-ceramic restorations were limited to anterior regions and single unit fixed prostheses. However, improvements to ceramic materials have increased their mechanical stability, while still promoting esthetic value (27). The new materials, leucite/lithium-disilicate glass ceramics and oxide ceramics such as alumina and zirconia, are very promising as seen in recent research (27). With some of these new materials, dentists can now use ceramics at posterior sites and even with multiple-unit fixed prostheses (27).

The advancements in today's materials have had a significant impact on materials of choice, specifically with patients that require esthetics. Dentists began to prefer non-metallic alternative materials due to the excessive cost of metal-based crowns, among other factors (3, 4, 26). Yet, separate from issues related to material decisions like tooth location, esthetics, patient desires, masticatory factors, and patient finances, is that with more and more options, decisions for restoration materials may also be associated with individual dental practices and characteristics. Consequently, decisions made may be unrelated to patient variables, which is something dentists need to recognize when choosing dental material (26).

To understand trends and practices in restoration, the goal of this study is to determine if there has been a shift in the material of crown production over recent years in the Graduate Prosthodontics Clinic at the University of Pittsburgh School of Dental Medicine.

2.0 Chapter 1

2.1 REVIEW OF LITERATURE

2.1.1 Porcelain-fused-to-metal (PFM) crowns

For more than 50 years, porcelain-fused-to-metal restorations have been the most used for crown and bridge material. The downside of using this material is ceramic chipping, gingival display of metal when gingival tissue recedes, and faulty color, which make them appear unnatural (1). In 2019, Glidewell laboratories reported that PFM crown production had decreased dramatically, to as low as 9 percent, compared to zirconia crowns, which comprised 75 percent of their production (2). From a cost perspective, precious metal is expensive and requires a great lab technician that can manage it. With precious metals being expensive, all ceramic crowns are being used more in dental industry due to excessive cost (4). Nevertheless, even though all-ceramic options have become more common, metal crowns are still a common choice due to excellence of strength and biocompatibility. Still, with high costs of noble metals and more demand for esthetics, the choice of full metal restorations has significantly decreased (26). Plus, for PFM crown to be esthetically acceptable, certain measurements are needed for reduction to mask the metal substructure. To mask the metal, more tooth reduction is required to achieve the desired esthetic results, or the crown will be thicker (5). Consequently, the clinician must accomplish different measurements to achieve good esthetic results which include marginal design and significant reduction of tooth structure (4).

To provide good physical properties and long-term durability for dental restoration, there are challenges to be met, no matter what the choice of materials may be, whether all-metal, metal ceramic or all ceramic materials are used. The preparation for any restoration is extensive, and can be even more intensive depending on materials. For example, to produce the metal-ceramic crown, a cast metal crown is veneered with a layer of porcelain to appear as a natural tooth (28). The natural tooth must be significantly reduced to make room for the restorative materials. Commonly, a 1.5 mm reduction is done that leaves more than 25% of teeth with a very small margin of peripulpal dentin (<0.5 mm) which leaves almost no room for error when preparing a tooth. In addition, too much pulp exposure can lead to a loss of vitality, which can cause early failure (28). Nevertheless, despite the challenges, PFM crowns are still widely used for full coverage restorations in the anterior and posterior aspect of the dentition.

Porcelain-metal restorations have an advantage of strength, but they have low esthetic appeal. Still, with improvements, good physical properties have been achieved with adequate bond strength between the metal and the porcelain which is why PFM crowns are widely used for full coverage restorations in the anterior and posterior aspect of the dentition. The chemical bonding between the porcelain veneer and the metal plays a significant role in the stability of the material to withstand functional loading (5). To overcome the challenge of fracture, it is necessary that the porcelain veneer does not exceed 2 mm in thickness, but at the same time, the minimal thickness of the porcelain should be not thinner than 1 mm to mask the metal substructure (5).

Obviously, PFM crowns have their limitations, so all-ceramic crowns have become an alternative. Nevertheless, simply inserting an all-ceramic restoration crown into a patient offers no guarantee of an esthetic or stable outcome (4). Just as with metal-ceramic crowns, there are many specific details required to prepare for a successful all-ceramic restoration. First, endodontic

assessment should be completed before preparing the tooth to determine pulpal health and whether it is advisable to proceed with a restoration crown (4). Next, proper preparation of the tooth with adequate reduction to provide enough room for the crown, along with sufficient contouring, are all essential to create a restoration with excellent esthetics (4). Creating enough access via reduction for PFM materials can be quite difficult, which has been shown to result in a serious defect (4). Margins need to be deep into the sulcus, but if too deep, minor gingival recession will expose them and potentially violate the necessary width which can cause chronic inflammation (4). Dr. Terence Donovan (2008) argues that PFM crowns require aggressive preparations, which could result in a biological price paid for the sake of better esthetics (4).

2.1.2 Zirconia crowns

One of the advantages of using an all-ceramic crown is the preservation of the tooth with less tooth removed during reduction as is needed for metal-ceramic crowns. Usually, 0.3 to 0.5 mm is adequate to obtain full coverage restoration for an all-ceramic crown. Despite the high esthetic results of all ceramic crowns, there are limitations to their use, including brittleness which makes them easy to fracture. The challenge comes in the stage of fabrication during processing and includes voids during sintering (7). To reduce the potential of fracture, advancement in materials used have developed. For example, monolithic zirconia and lithium disilicates have been introduced that exhibit not only more strength with less fractures (5), but also higher esthetics (19). Consequently, all-zirconia crowns have gained popularity due to their high strength, durability and wearability, along with low cost.

Zirconia is a computer-aided design/computer aided manufacturing (CAD/CAM) bilayer restoration with excellent mechanical characteristics, including high flexural strength (700 - 1,200 MPa), fracture toughness (7 - 10 MPa·m1/2), hardness, translucency, chemical stability, biocompatibility, and desirable appearance (19). The zirconia is coated with a feldspathic ceramic veneer which optimizes the esthetic results of color and translucence (19). A final contour wax is applied to the core, which is eliminated when heated. Then the ceramic is heat-pressed onto the core. This layering provides both accuracy and stability (19).

The use of CAD/CAM systems has many advantages. They include higher quality and more uniform restorations, more standardization, and reduced costs in production time (9). There are some disadvantages as well. The scanning process does not have very high resolution, and edges can become rounded. The system also uses a software algorithm to create a smooth,

unbroken surface, but this can lead to some inaccuracies which can cause problems in the margins of the incisal or occlusal edges (9).

Zirconia also has a tooth-like appearance that mimics the natural optical properties of teeth. There are many reasons why so many practices are leaning towards metal free restorations due to high esthetics results. In addition, the high rise in metal cost is certainly a highly motivating factor (6). Yet, some dentists may not choose all-zirconia because they fear there will be degradation of strength over time (26).

Uncertainty about long-term durability of Zirconia-based technology in dental restoration is understandable considering the technology is still in its infancy. Still, when zirconia is layered with a translucent ceramic like porcelain, it is a distinctive esthetic choice. So, in spite of uncertainty, the development of zirconia crowns has increased over the years due to their aesthetic capability, biocompatibility, and wear resistance. Although zirconia crowns have not been as extensively tested as porcelain-metal crowns, the testing that has been completed shows that the fracture strength of a PFM crown that has 1.5 mm reduction is similar to zirconia crowns with only 1mm reduction. Some dentists believe the zirconia crowns should be used to preserve more of the tooth (26).

Much more needs to be understood about how zirconia crowns compare to other ceramic-fused metal technologies (4). What is known is the core of the zirconia are excellent, and they also possess “transformation toughening” (4). The term refers to development of defects from the transformation of the tetragonal form to the monoclinic form. Clinical trials indicate there will be a high success rate with the physical aspects of zirconia crowns (4).

The zirconia substructure typically has a flexural strength of 1200 MPa, which is comparable to conventional porcelain fused to metal crowns. The ceramic-zirconia crown has

tested with higher fracture toughness and flexural strength of zirconia are significantly higher than of alumina or any other all-ceramic materials (29). With porcelain layering, no metal is visible and have excellent biocompatibility. The crowns are easy to adjust with a green stone or a diamond bur.

With the advanced technology of CAD/CAM scanners, clinicians can provide final restorations with same day delivery to patients. Digital scans for final crowns can provide similar quality of outcomes as conventional impressions, which makes it easier for the clinicians (8, 19).

2.1.3 Marginal fit

PFM crowns remain a popular choice for fabricating crowns and bridges due to their high strength properties and superior fit of casting. On the other hand, with the development of computer-aided design (CAD) and computer-aided manufacturing (CAM) the trend has changed to zirconia for full coverage restorations. The CAD/CAM system led to an increase in crown production, increased crown quality, and reduced time in the chair (9,10). There are many studies that evaluated marginal fit and internal gap between zirconia and conventional PFM crowns. Some studies supported that zirconia crowns have better marginal fit and internal adaptation and some reported the opposite. These controversial results are due to different methods used to measure the difference in fit and internal adaptation. A recent study by Paul et al. (2020) revealed the lack of standardization in marginal fit measures, especially with gap measurements (9). Additionally, other factors need to be considered when evaluating fit, including cementation. Paul et al. used the impression technique, which is one of the basic methodologies to check the internal and marginal fit. Like several other studies that used this technique, Paul et al. found that zirconia crowns have better marginal and internal adaptation than conventional PFM crowns (9,11,12,13).

2.1.4 Shear bond Strength

Shear bond strength is one of the most researched topics regarding PFM crowns. Most studies approve of the high shearing strength of PFM full coverage restorations (14,15,16). Recently, with the increased demand for esthetics, more research has been introduced to test the shearing strength of zirconia. The results have been disappointing.

Although Zirconia is a durable material, a lot of complications are seen with FPD (fixed partial dentures) such as chipping off of the veneered porcelain which is believed to be due to the relatively low coefficient of thermal expansion and thermal diffusivity of zirconia compared to traditional metal which has manifested as veneer chipping and delamination (6,7,8) over time (9, 27). The fracture rate of the veneering ceramic ranges from 8 to 50 percent at one and two years (4), while fracture veneer with metal-ceramic is between 4 and 10 percent after 10 years (4) Nevertheless, the exact reason for veneer chipping seen in zirconia restorations is still not well understood (19). There are a variety of possible causes, including defects in the veneer, mistakes in cooling rates, weak chemical bonding of the core and the veneer, and traumatic occlusion (4, 15,17,19) due to a chemical bond gap between the veneered material and the zirconia (4, 15,17). Another factor that can affect the bond strength is surface treatment. Examples such as airborne abrasion, application of line, sandblasting with aluminum oxide will enhance the bond strength (18,19,20). Another cause could be the lack of uniform support of the ceramic by the core. It is well known that with metal-ceramic restorations, the core needs to have uniform thickness, with no more than 2 mm of unsupported porcelain (4).

Because zirconia has many valuable qualities, more research is being conducted to test the use of different materials to overcome the problems with zirconia crowns such as Fluorapatite

ceramics used over zirconia frameworks and Leucite containing ceramics for veneering a zirconia framework (19). Both have shown improved bonding and fracture resistance (19).

Obviously, the type of materials used in restoration are essential to desirable outcomes; however, other factors have to be considered as well. Tooth preparation is critical to success, as well as close attention to cervical margin design, management of soft tissues and precise impression techniques (4). Matching high-quality dental methods with high-quality materials will have higher levels of success in the long-term. The only way to be sure of the long-term quality of materials will require extensive testing and studies so dentists can be sure of which options are best for each of their patients.

3.0 Research Objective

The goal of this study is to determine the material of choice in recent years in the Graduate Prosthodontics Clinic at the University of Pittsburgh School of Dental Medicine. Recent studies have shown different material of choice depending on years of experience, type of practice, lab technician expertise, etc. (22,23).

3.1 Research hypothesis

Zirconia crowns as a treatment of choice will not have increased in recent years, compared to PFM crowns, in the Graduate Prosthodontics Clinic at the University Of Pittsburgh School Of Dental Medicine.

4.0 Chapter 2

4.1 Search methods:

4.1.1 Statistical analysis:

Axium was used to extract data for two different residents who worked over different years at the Graduate Prosthodontics Clinic at the University Of Pittsburgh School Of Dental Medicine. The residents were chosen due to their high productivity in there graduate year. The protocol of this study is approved by the University of Pittsburgh Institutional Review Board and the IRB.

The codes that were used include: full metal crowns [D2790, D2792, D6210], PFM crowns [D6240, D6242, D6750, D6752, D2750, D2752], and Zirconia crowns [D6750, D2740, D6245] were searched. Pivot charts were used to collect data. Chi-square test with an alpha of 0.05 were used to test whether sets of frequencies of crowns produced follow certain patterns.

5.0 Chapter 3

5.1 Results

Table 1 Frequency of codes found.

Material	Count of Code Row Labels	Column Labels R 2016	R 2018	Grand Total	P Value
	D2740	30	51	81	**0.002**
Zirconia	D2740X	1		1	
	D6245	9	23	32	
	D6740	6	22	28	
	D2790	1	3	4	
All metal	D2792	1		1	**0.27**
	D6210		5	5	
	D6240	17	29	46	
	D6242	18	27	45	
	D2750	30	70	100	
	D2752	34	40	74	
PFM	D6750	24	54	78	**1**
	D6752	27	41	68	
	Grand Total	**198**	**365**	**563**	

Table 1 shows the results for crown production for two different residents who graduate in 2016 and 2018, respectively. The Resident who graduated in 2016 performed a total of 150 PFM crowns, 46 Zirconia crowns, and 4 full metal crowns in 3 years of residency, for a total of 198 crowns. Chi-square test was used to get P value.

The Resident who graduated in 2018 performed a total of 261 PFM crowns, 96 zirconia crowns, and 8 full metal crowns for a total of 365 crowns in 3 years.

When comparing PFM crowns production between the different years R2016 with total of 150 crowns, and R2018 with total of 261 crowns with P value of 1 using Chi-square test. The present results show that the PFM crown production by the graduate prosthodontic clinic is still the same.

For zirconia production R2016 had a total of 46 crowns and R2018 had total of 96 crowns with P value 0.002. The results show that there has been an increase in production of zirconia crowns in recent years.

For all metal crown date, R2016 had total of 2 crowns and R2018 had total of 8 crowns with P value 0.27. The results are not significant.

Table 2. Comparing codes for single crowns and fixed partial denture codes for zirconia and PFM for resident R2016 and R2018.

Material	Codes description	Count of Code Row Labels	Column Labels R 2016	R 2018	Grand Total	P Value
	Single crown	D2740	30	51	81	**0.745**
Zirconia	**FPD**	D6245	9	23	32	**0.044**
		D6740	6	22	28	
	Single crown	D2750	30	70	100	**1**
		D2752	34	40	74	
	FPD	D6240	17	29	46	**0.83**
		D6242	18	27	45	
PFM		D6750	24	54	78	
		D6752	27	41	68	
		Grand Total	**196**	**357**	**553**	

Table 2 shows the individual P value for single crown codes versus fixed partial dentures of the two materials PFM and zirconia. In the present data it shows that there has been an increase in zirconia fixed partial dentures in recent years.

6.0 Chapter 4

6.1 Discussion

The present analysis provides useful new data that there is an increase in zirconia crown production in the Graduate Prosthodontics Clinic at the University of Pittsburgh School of Dental Medicine in recent years. Since the p-value for comparing zirconia crowns in different years is less than 0.05, we rejected the null hypothesis that there were no differences in production over time at the department. Studies show that zirconia crowns are being used more often in recent years due to their improved physical properties and esthetics (5,6).

Patients are more aware of dentistry these days due to advertising and social media. Patients are much more engaged in their treatment planning and the choices they make for their oral health. The greater the knowledge the patients have the more questions they will ask about material of choice and esthetics. Most of the patients are looking for metal free restorations. Dentists should provide patients with the best treatment that provides durability and aesthetics. Metal free restorations such as zirconia have great advantages such as: chromatic stability, biocompatibility, low plaque retention, low thermal conductivity, esthetic appearance, and wear resistance. On the other hand, some of the limitations of early dental ceramics include brittleness, low tensile strength and fracture toughness, ease of crack propagation and difficulty of repair (24).

The study showed that there is no significant difference in PFM crown production in different years. PFM crowns remain the gold standard in prosthetic dentistry due to their great

mechanical properties, perfect marginal fit and adaptation. Dentists should make the final judgment of which material of choice is more suitable for the patient.

The study presented that zirconia is used more now for bridges than previous years. In many reported studies, after three years of clinical service, zirconia FPDs have exceptionally good clinical outcomes with failure rates between 0% and 4.8% (25).

7.0 Chapter 5

7.1 Conclusion

- There is a trend toward using zirconia crowns and FPDs in the graduate Prosthodontics clinic at the University of Pittsburgh School of Dental Medicine.
- There has been a shift in the material of crown production over recent years in the Graduate Prosthodontics Clinic at the University of Pittsburgh School of Dental Medicine.

8.0 Appendix

University of Pittsburgh | Institutional Review Board
Office of Research Protections

EXEMPT DETERMINATION

Date:	July 12, 2021
IRB:	STUDY21070015
PI:	Alexandre Vieira
Title:	Comparison of Crown Production Over the Years at the School of Dental Medicine
Funding:	None

The Institutional Review Board reviewed and determined the above referenced study meets the regulatory requirements for exempt research under 45 CFR 46.104.

Determination Documentation

Determination Date:	7/12/2021
Exempt Category:	(4) Secondary research on data or specimens (no consent required)

Determinations:	• Waiver of HIPAA authorization
Approved Documents:	• form, Category: IRB Protocol;

If you have any questions, please contact the University of Pittsburgh IRB Coordinator, Ali Arak.

Please take a moment to complete our Satisfaction Survey as we appreciate your feedback.

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