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Research Article

Fracture Resistance of PFM Crowns in Daily Dental Practice

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Abstract: ***Background:*** Porcelain-fused-to-metal (PFM) crowns are widely used in clinical dentistry due to their strength and aesthetic qualities, with the metal substructure offering durability and the porcelain veneer providing a natural appearance. The purpose of this study was to evaluate the fracture resistance of porcelain-fused-to-metal (PFM) crowns in routine dental practice. ***Aim of the study:*** The aim of this study was to evaluate the fracture resistance of PFM crowns in daily dental practice. ***Methods:*** This prospective observational study took place in the Department of Prosthodontics at BSMMU and beau-dent, Dhaka, Bangladesh, from January to December 2014, involving 100 patients who received PFM crown restorations. Participants provided informed consent, and data collected included demographics, crown location (anterior or posterior), and porcelain thickness. Failure modes (metal core fracture, porcelain chipping, combined failure) were monitored. Outcomes were analyzed using SPSS version 22.0. ***Results:*** In this study on the fracture resistance of PFM crowns in daily dental practice, 40% of crowns demonstrated fracture resistance greater than 1100 N. The most prevalent failure mode was porcelain chipping, occurring in 55% of cases, highlighting the susceptibility of the porcelain layer to stress-related damage. Fracture resistance varied based on crown location, with 60% of crowns placed in the posterior region. Additionally, the fracture resistance of PFM crowns also varied based on porcelain thickness, with 70% of crowns having a thickness between 1.0–1.5 mm. ***Conclusion:*** This study underscores the durability of PFM crowns, highlighting that material strength, design, and clinical factors are crucial for their long-term performance.
Keywords: Fracture Resistance, PFM Crowns, Dental Practice, Porcelain Veneer, Metal Substructure.

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INTRODUCTION

Porcelain-fused-to-metal (PFM) crowns are commonly used in clinical dentistry because they offer both strength and aesthetic appeal.[1] The metal substructure provides the crown with strength, while the porcelain veneer delivers a natural, pleasing appearance.[2] These crowns are ideal for restoring severely damaged teeth, protecting remaining tooth structure, and maintaining proper occlusion.[3] The bonding between the porcelain and metal is achieved through a combination of van der Waals forces, mechanical interlocking, chemical bonds, and the compressive forces created by the differing thermal expansion coefficients of the materials.[4] This interaction helps improve the crown's durability and longevity.

Fracture resistance is a key factor in ensuring the long-term success of PFM crowns in everyday dental practice. These crowns must be able to withstand the occlusal forces encountered during normal chewing. Any mismatch in size between the metal substructure and the porcelain veneer can increase the stress on the crown, leading to fractures.[5] This issue is further exacerbated by the crown's design, where certain structural elements may lack adequate support, raising the risk of failure. Research has shown that the most common technical complications in metal-ceramic restorations, including PFM crowns, are fractures of the porcelain veneer. The design of the framework and the methods used for manufacturing play a crucial role in determining the failure rates and fracture patterns of the crowns, emphasizing the importance of careful design and appropriate material selection.[6,7,8]

Previous studies have extensively explored various factors influencing the fracture resistance of porcelain-fused-to-metal (PFM) crowns. For instance, the inadequacy of the metal framework has been frequently linked to porcelain fractures,[9] while porcelain chipping in layered crowns is a common cause of clinical failure.[10] Additionally, defective cast crowns may lead to issues such as food impaction and caries in adjacent teeth, often caused by faulty contact points, which negatively impact the restoration's overall success.[11] Research also highlights the significant role of the metal substructure design in ensuring sufficient strength and preventing fractures. Sharp edges on the metal frame can create stress concentrations, weakening the bond between the porcelain and metal.[12] Moreover, the absence of passive fit in screw-retained restorations can lead to mechanical deformations and stress concentrations, ultimately resulting in porcelain fractures.[9]

Given these concerns, evaluating the fracture resistance of PFM crowns in clinical practice is essential for improving patient care and optimizing material selection. The design of the metal substructure, including the thickness and distribution of the porcelain, plays a key role in the crown's longevity and durability. Ensuring the porcelain thickness is appropriately distributed (between 1.5 and 2 mm) can significantly reduce the risk of fractures.[13] Additionally, understanding how various materials and structural designs influence fracture resistance can guide clinicians in selecting the most suitable crowns for individual patients. While some studies have investigated the fracture resistance of zirconia crowns, similar research focused on PFM crowns is needed to predict their clinical behavior and improve restorative outcomes.[14,15] The purpose of this study was to assess the fracture resistance of porcelain-fused-to-metal (PFM) crowns in routine dental practice.

Objective

- The aim of this study was to evaluate the fracture resistance of PFM crowns in daily dental practice.

METHODOLOGY AND MATERIALS

This prospective observational study was conducted in the Department of Prosthodontics at Bangabandhu Sheikh Mujib Medical University (BSMMU) and beau-dent, Dhaka, Bangladesh, from January 2014 to December 2014. A total of 100 patients who received PFM crown restorations were enrolled in the study.

Inclusion Criteria:

- Patients requiring single PFM crowns for either anterior or posterior teeth.
- Individuals who provided written informed consent for participation in the study.

Exclusion Criteria:

- Patients with multi-unit restorations.
- Individuals with pre-existing dental conditions affecting crown integrity.
- Patients with systemic conditions affecting oral health.

Clinical data, including demographic information (age, gender) and the location of the crown (anterior or posterior), were recorded. Additionally, the porcelain thickness of each crown was documented. The failure modes of PFM crowns were classified into three types: metal core fracture, porcelain chipping, and combined failure (core + porcelain), and these outcomes were monitored during the study period. Data were compiled and analyzed using SPSS version 22.0, employing descriptive statistics to summarize participants' demographics and clinical characteristics. Frequencies and percentages of fracture resistance values, failure modes, crown location, and porcelain thickness were calculated.

RESULTS

Table 1: Distribution of Fracture Resistance of PFM Crowns (n=100)

Fracture Resistance (N)	Frequency (n)	Percentage (%)
500–700	10	10.00%
701–900	20	20.00%
901–1100	30	30.00%
>1100	40	40.00%
Total	100	100.00%

The most common fracture resistance range was greater than 1100 N, with 40 crowns (40%) falling into this category. This was followed by the 901–1100 N range, with 30 crowns (30%) exhibiting fracture resistance in this range. A total of 20 crowns (20%) were found to have a fracture resistance between 701–900 N, while the least common range was 500–700 N, with 10 crowns (10%) showing fracture resistance in this category.

Table 2: Distribution of Failure Modes in PFM Crowns (n=100)

Failure Mode	Frequency (n)	Percentage (%)
Metal Core Fracture	15	15.00%
Porcelain Chipping	55	55.00%
Combined Failure (Core + Porcelain)	30	30.00%

The most prevalent failure mode was porcelain chipping, occurring in 55 cases (55.00%), highlighting the susceptibility of the porcelain layer to stress-related damage. Combined failures involving both the metal core and porcelain accounted for 30 cases (30.00%), reflecting the complex interplay of structural and material weaknesses under loading conditions. The least common failure mode was metal core fracture, recorded in 15 cases (15.00%), emphasizing the inherent durability of the metal substructure in PFM crowns under most clinical conditions.

Table 3: Fracture Resistance Distribution Based on Crown Location (n=100)

Crown Location	Frequency (n)	Percentage (%)
Anterior	40	40.00%
Posterior	60	60.00%

The fracture resistance of PFM crowns varied based on their location within the mouth. A total of 60 crowns (60%) were placed in the posterior region, while 40 crowns (40%) were placed in the anterior region.

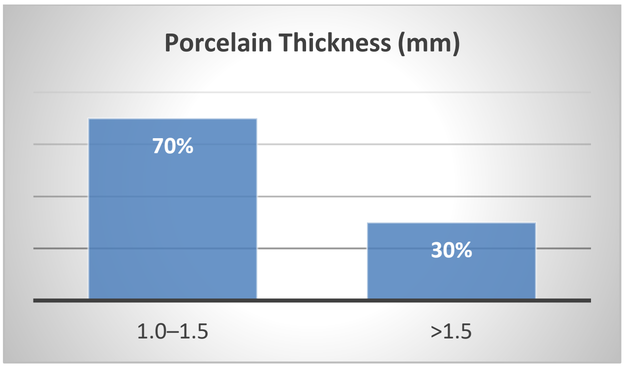

Figure 1: Distribution of Fracture Resistance by Porcelain Thickness

The fracture resistance of PFM crowns varied based on the thickness of the porcelain layer. A total of 70 crowns (70%) had a porcelain thickness between 1.0–1.5 mm, while 30 crowns (30%) had a thickness greater than 1.5 mm.

DISCUSSION

This study examines the fracture resistance of porcelain-fused-to-metal (PFM) crowns, a critical factor in ensuring the longevity and durability of dental restorations. PFM crowns are widely used in clinical practice due to their balance of strength and aesthetics, making them ideal for restoring damaged teeth. However, their ability to withstand occlusal forces over time is essential for long-term success. The findings of this study reveal the distribution of fracture resistance across various ranges, highlighting the significant variation in outcomes based on crown location and porcelain thickness. Furthermore, the study identifies porcelain chipping as the most prevalent failure mode, emphasizing the need for optimal crown design to minimize stress-related damage. These results underscore the importance of understanding the factors influencing fracture resistance to improve the selection and design of PFM crowns for better clinical outcomes.

In our study, the fracture resistance of PFM crowns in daily dental practice revealed that 40.00% of crowns had fracture resistance greater than 1100 N. This aligns with Wang et al.'s[16] findings, where the highest fracture resistance was observed at approximately 2316 N. Additionally, 30.00% of crowns in our study fell within the 901–1100 N range, similar to the lower resistance values noted by Wang et al.[16] at around 1090 N, further suggesting that variations in fracture resistance can exist depending on material and design. These similarities emphasize the critical role of material strength and substructure design in ensuring the longevity and performance of PFM crowns in both implant-supported and routine dental practices.

In our findings, porcelain chipping (55%) was the most frequent mode of failure, resonating with Liu et al.'s[17] observations of Hertzian cone cracks and delaminations as precursors to chipping. These patterns emphasize the critical need to manage stress concentrators, particularly in occlusal areas prone to repetitive loading. Additionally, the combined failures (30%) observed in our study align with their documentation of fracture propagation at the porcelain-core interface, which remains a weak link in bilayer crown designs. The lower prevalence of metal core fractures (15%) further echoes their findings, which highlighted the resilience of metal cores except under severe stress conditions. Such parallels underscore the clinical importance of optimizing material interfaces and mitigating stress to reduce failure rates in porcelain-fused-to-metal crowns.

In this study on the fracture resistance of PFM crowns in daily dental practice, we found that posterior crowns exhibited superior fracture resistance (60%) compared to anterior crowns (40%). This difference likely arises from the greater occlusal forces experienced by posterior crowns during chewing. These findings highlight the importance of considering functional demands when selecting crowns, as posterior crowns require enhanced durability, while anterior crowns, primarily used for aesthetics, can tolerate slightly lower strength. Thus, personalized treatment planning, based on the crown location and expected forces, is crucial for ensuring long-term durability and optimal performance of PFM crowns in clinical practice.

In this study, the majority of crowns (70%) fell within the 1.0–1.5 mm porcelain thickness range, which aligns with Ferrari et al.'s[18] findings that suggest this range offers a balanced combination of strength and esthetic appeal in PFM crowns. They observed that crowns with greater porcelain thickness (over 1.5 mm) exhibited enhanced fracture resistance, a trend that is also visible in our data, where the remaining 30% of crowns with porcelain thickness greater than 1.5 mm demonstrated improved durability. This supports their conclusion that increased porcelain thickness contributes to greater fracture resistance by improving stress distribution. The similarity in both studies highlights the clinical significance of selecting an optimal porcelain thickness to ensure both functional longevity and esthetic quality in dental restorations.

This study underscores the importance of fracture resistance in PFM crowns, with key factors such as porcelain thickness and crown location influencing their durability. These findings contribute to optimizing crown selection and design for improved clinical outcomes.

Limitations of the study

This study had some limitations:

- The sample size was relatively small, which may limit the generalizability of the findings.
- The study's limited geographic scope may introduce sample bias, potentially affecting the broader applicability of the findings.
- The evaluation period was short, lacking long-term outcome data to fully assess the durability and performance of PFM crowns.

CONCLUSION

This study provides a comprehensive evaluation of the fracture resistance of PFM crowns in daily dental practice. Our results indicate that 40% of PFM crowns exhibited fracture resistance greater than 1100 N, underscoring their durability. Porcelain chipping was the most prevalent failure mode, occurring in 55% of cases, highlighting the vulnerability of the porcelain layer. Fracture resistance varied by crown location, with 60% of crowns placed in the posterior region, and by porcelain thickness, with 70% of crowns having a thickness between 1.0–1.5 mm. These findings emphasize the critical role of material strength, design, and clinical factors in ensuring the longevity and performance of PFM crowns.

REFERENCES

1. Ikai H, Kanno T, Kimura K. A review of clinical follow-up studies focusing on pretreatment conditions of abutment and clinical examination parameters. Nihon Hotetsu Shika Gakkai Zasshi. 2006 Apr 1;50(2):245-55.
2. Etman MK, Woolford MJ. Three-year clinical evaluation of two ceramic crown systems: a preliminary study. The Journal of prosthetic dentistry. 2010 Feb 1;103(2):80-90.
3. Jalalian E, Jannati H, Mirzaei M. Evaluating the effect of a sloping shoulder and a shoulder bevel on the marginal integrity of porcelain-fused-to-metal (PFM) veneer crowns. J Contemp Dent Pract. 2008 Feb 1;9(2):17-24.
4. Bagby M, Marshall SJ, Marshall Jr GW. Metal ceramic compatibility: a review of the literature. The Journal of prosthetic dentistry. 1990 Jan 1;63(1):21-5.
5. Pjetursson BE, Brägger U, Lang NP, Zwahlen M. Comparison of survival and complication rates of tooth-supported fixed dental prostheses (FDPs) and implant-supported FDPs and single crowns (SCs). Clinical oral implants research. 2007 Jun;18:97-113.
6. Miller LL. Framework design in ceramo-metal restorations. Dental Clinics of North America. 1977 Oct 1;21(4):699-716.
7. Shelby DS. Practical considerations and design of porcelain fused to metal. The Journal of Prosthetic Dentistry. 1962 May 1;12(3):542-8.
8. Marker JC, Goodkind RJ, Gerberich WW. The compressive strength of nonprecious versus precious ceramometal restorations with various frame designs. The Journal of Prosthetic Dentistry. 1986 May 1;55(5):560-7.
9. Agar JR, Cameron SM, Hughbanks JC, Parker MH. Cement removal from restorations luted to titanium abutments with simulated subgingival margins. The Journal of prosthetic dentistry. 1997 Jul 1;78(1):43-7.
10. Newton RG, Davison S. Conservation of Glass. Butterworth - Heinemann Series in Conservation and Museology. London: Butterworths; 1989.
11. Special Report: Addressing Concerns About Lead, an ADA Study. ADA Professional Product Review. 2009;4:14–5.
12. Sgrò S. Principles of the Metal Framework Design in Metal-Ceramic Reconstructions. Quintessence of Dental Technology (QDT). 2002 Feb 1;25.
13. Chen Y-C. Biomechanical Study in Metal Substructure Design of Implant-Supported Porcelain-Fused-to-Metal Crown. [Master's thesis]. Graduate Institute of Dental Sciences, Kaohsiung Medical University; 2007.
14. Sornsuwan T, Ellakwa A, Swain MV. Occlusal geometrical considerations in all-ceramic pre-molar crown failure testing. Dental Materials. 2011 Nov 1;27(11):1127-34.
15. Kokubo Y, Tsumita M, Kano T, Fukushima S. The influence of zirconia coping designs on the fracture load of all-ceramic molar crowns. Dental Materials Journal. 2011;30(3):281-5.
16. Wang CH, Wu JH, Li HY, Wang PP, Lee HE, Du JK. Fracture resistance of different metal substructure designs for implant-supported porcelain-fused-to-metal (PFM) crowns. Journal of Dental Sciences. 2013 Sep 1;8(3):314-20.
17. Liu Y, Liu G, Wang Y, Shen JZ, Feng H. Failure modes and fracture origins of porcelain veneers on bilayer dental crowns. International Journal of Prosthodontics. 2014 Mar 1;27(2).
18. Ferrari M, Giovannetti A, Carrabba M, Bonadeo G, Rengo C, Monticelli F, Vichi A. Fracture resistance of three porcelain-layered CAD/CAM zirconia frame designs. Dental Materials. 2014 Jul 1;30(7):e163-8.