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A LITERARY REVIEW ON THE DIFFERENT ASPECTS CAUSING FAILURES OF METAL CERAMIC FIXED PARTIAL DENTURES

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ABSTRACT Metal Ceramic FPDs are a type of fixed prosthesis that combines the strength and durability of metal with the aesthetic properties of ceramic making it an excellent treatment modality. However, over the years different treatment options have pushed back Metal ceramic due to the gradual rise in failures. This article analyzes the different aspects that are involved in metal ceramic failure and the major causation of loss of restoration.

KEYWORDS : Metal Ceramic Fpds, Failures, Alloys, Titanium, Collarless Metal Ceramic, Fractures

INTRODUCTION:

Fixed Partial Dentures are one of the most successful treatment options for an edentulous patient. Metal ceramic crowns are a type of FPD. The durability of metal and the aesthetic feature of ceramic make it an excellent choice of treatment modality. Metal Ceramic Crowns are a hybrid of metal and ceramic crowns. The failures of metal ceramic crowns depend on various factors such as properties of metal alloy chosen, the bonding of ceramic to metal, aesthetic finish, function, retention, mechanical failure, design failure, changes in the abutment tooth and occlusal problems. Another main factor is the ceramic bonding to the metal framework. This literary review compares the various studies discussing metal ceramic FPDs and their failure rates. This can help in enhancing the clinical survival of metal ceramic crowns and also to address the revealing yet not altered challenges. Every dental procedure has it challenges and it is important to address them. Understanding these challenges can provide imminent scope for development. Metal ceramic failures, can be grouped into many. Namely, Biological, Mechanical and Aesthetic. Though studies have proven that Metal ceramic FPDs have a higher survival rate, comparatively, other aspects of a successful fixed restoration must also be taken into consideration. A vast range of systematic reviews have stated metal ceramic FPDs to be successful, but probing further, lab and clinical research have pointed out various defects in the design and patient comfort. Moreover, changes and corrections are always inevitable for perfection and success.

History:

- The use of ceramics in dentistry started in 1889 by Charles H.Land, who introduced the all porcelain jacket crown and modified by E.B.Spaulding.
- Abraham Weinstein introduced porcelain-fused-to-metal (PFM) crown in the 1950s.
- The bond between the metal and porcelain prevented internal microcracking, which was responsible for the failure of the jacket crown.
- Lost-wax fabricated metal copings led to better marginal fit of the PFM restoration than the Porcelain jacket crowns.
- Some of the challenges PFM alloys had to overcome were construction of the restoration frameworks along with consideration of the chewing forces to be absorbed, so as to prevent fracture of the restoration.
- Prefabricated bridge units also known as Inzoma[37] technique were introduced for good distribution of compressive and tensile forces.
- Though various techniques such as the refined layering technique, and the Golden Gate system and Carrara system provided good insights and possibilities for development of metal ceramic restorations, there is still a demand for more advanced, yet, simplified products.

Properties:

- The strength of the metal ceramic restoration depends on the homogenous bond between alloy and ceramic layers. 1.2-1.5 mm is made of ceramic material and 0.5 mm of alloy, the occlusal forces are directed on the alloy framework. Compressive stress is given on the upper region whereas tensile stress is given in the underside. The tensile stress should not exceed the compressive stress, if this were to happen it would lead to fracture of the restoration.
- Another important factor that decides strength of metal ceramics is the varying coefficient of thermal expansion of the alloy and the ceramic. The coefficient of ceramic must be lower than that of alloy, so that the veneering ceramic is put under compressive stress.
- Alloys must have high heat resistance higher than that of the ceramic to prevent the framework from sagging also known as sag resistance.

Requirements:

- 1.2-1.5 mm thickness of veneering ceramic
- 0.3-0.5 mm thickness of alloy
- Connector thickness is very important for withstanding the occlusal load. The occlusal load different for posterior teeth and anterior teeth. In a 3 unit PFM restoration connector thickness should be 3-5 mm in posterior region and 2.5-4mm in anterior. Whereas in a 4 unit restoration it should be 3.8-6 mm in posterior and 3-5 mm in anterior.
- U-shaped connector design
- 1.2-1.3 mm occlusal reduction and 1.5-1.6 mm incisal reduction
- Thickness of the coping should be 0.3-0.5 mm for anterior and 0.5-0.8 mm for posterior

Indications:

- Aesthetic demands
- More durable than all ceramics
- In case of extensive tooth loss
- Correction of malocclusion and occlusal plane

Contraindications:

- Patients with active caries and periodontal diseases
- Risk of pulp exposure in young patients with large pulp chambers

Advantages:

- Better strength when compared with All ceramics
- Good retention

Disadvantages:

- More amount of tooth removal
- Sub gingival facial margins lead to PDL disease
- Poor Aesthetics compared to all ceramics
- Many procedural steps

Discussion:

This study focuses on metal ceramic FPD fabricated in the conventional methods.

Metal Ceramics were considered to be one of the longstanding treatment modalities for replacement of teeth, hence innumerable studies were done to analyze its failure, so as to find any breakthrough in metal ceramic restorations.

Some of the research done over the years have stated that tooth fracture is one of the main reasons behind metal ceramic failures and also that

metal ceramic FPDs had 7 times higher rate of failure in case of bruxism patients without any protection device to the restoration.

On the basis of types of metal, porcelain fused metal titanium restorations after a six year follow up indicated high failure rate. Whereas, a three to seven year study on cobalt chromium, did not feature any complaints from the patient side regarding side effects of the metal, but did show many technical and biological failures. Any fixed partial denture owes its success to the compatibility and design of its parts. To begin with a study done on dimensions of the framework of a metal ceramic FPD showed that the dimensions were unrelated to the FPD size as well as span. In a 2D element study, metal ceramic proved to have the least stress value of 194, when the load was applied to the abutment teeth, but the same cannot be said when it comes to physiologic and pontic load. Also on applying loads of 100 N, it was found that connectors had the highest area of failures. Apart from these, gingival bleeding on probing and non-aesthetic appearance was also stated to be one of the issues of metal ceramic restorations. Post cementation hypersensitivity, though not to a great extent, also posed problems in patients.

The search for the best is a never ending quest, so is the case in the rehabilitation of teeth. There has been an influx of studies regarding the durability of metal ceramic. Metal ceramic is also always pitted against All ceramic. The comparisons and questions never seem to decrease.
There seems to be a decline in articles related to metal ceramic and its failures as the year's progress, this may be due to the newer and better properties of materials like Zirconia and various advanced fabrication procedures.

Classification of Fractures in metal ceramics:
Friedman[1] classified porcelain fractures into:

1. Static fracture: A segment of porcelain fractures but remains intact.
2. Cohesive fracture: fracture occurs within the body of porcelain due to tensile loads
3. Adhesive fracture: failure of bonding interface between porcelain and substrate

Haselton *et al*[2] classified metal ceramic fractures into:

1. Simple: involving only porcelain
2. Mixed: involving both metal and porcelain
3. Complex: where a large area of metal framework is exposed

Theoretically, metal ceramic failures are classified into:

- Biologic: tooth structure, over contouring, supragingival margins, occlusion, tooth fracture
- Aesthetic: Display of metal, Thickness of Porcelain, Subgingival margin
- Mechanical: Retention and Resistance form, Deformation of the restoration

Biologic Failures:

Biologic failures were found to be limited in case of metal ceramic restorations. A 20 year follow up study found patients with root fractures due to failure of endodontic postsalong with occlusal wear in the opposing teeth [5]. A clinical study done in 2012 found in a patient pain and infection.[22] In cases of patients with increased overbite, excessive non axial forces are generated due to increased vertical overlap, this in turn may lead to fracture.[38] A prosthesis where these forces are controlled is required in such cases. Biologic fractures may also be attributed to lack of marginal integrity which leads to microleakage leading to breakdown of the restoration.

Aesthetic Failures

Aesthetics plays a very important role in restoration or replacement of the tooth structure. The patient will not only want the replacement of his or her lost tooth, but also the lost aesthetic features, that define them personally. Hence, this aspect needs special consideration. 20 year follow up study stated though patients had aesthetic problems.[5] Over contoured restorations lead to poor aesthetics (also known as the umbrella effect). [12] , likewise due to complaints regarding aesthetics 22 metal crowns were replaced over a clinical service of 14 years.[33] A male patient had an accident, which led to the fracture of his restoration. Though, the fracture occurred only to the ceramic portion, the patient was largely concerned with the unaesthetic appearance. [22] Another patient, female faced ceramic fracture in her maxillary posterior teeth, she was found to be deeply concerned with the underlying metal which revealed itself after the fracture. [22] Though the ceramic covers up the metal below, to provide with good aesthetic features, it is an undeniable fact that any fracture to the restoration can make the patient worry due to the showing of the metal core[28] next to the high discomfort resulting from the fracture of course.

Mechanical Failures:

Mechanical failures can be caused to due to any accident to the patient, mistakes done in the laboratory during fabrication or while operating the patient. Materials that are used in the fabrication can also play a role in failure. Trauma is a major cause of fracture. [21] Occlusal interferences in the crowns were found to cause stresses that create 'Hertzian cone cracks' which may lead to chipping of the restoration. [20] Another study showed that there was 95% chipping in PFM restorations.[24] Chipping and loss of retention occured during the first few years during a retrospective study of clinical performance of porcelain fused metal ceramic crowns. [35] and a mean chipping rate of 2.9% was observed after a 5 year study.[11] Parafunctional habits such as clenching and bruxism lead to repetitive loading, which expose the restorations to greater occlual loads, which as a result cause fracture of the crown. [3] [16] A 152 patient study found that patients with bruxism had the highest number of failures. [7] A 10 year study in a private practice scenario also reported patients who had fractures due to bruxism. [32]The part of the dentist in the fracture of the restoration, also plays a major part in the failure. Insufficient tooth reduction[37], which can result in overcontoured, bulky crown[6], knife edge margins, which can cause chipping very easily are some of the mistakes done by clinicians. Also, feather edge finish lines were found to give more mechanical disadvantage in many cases.[9] In another study 4mm incisal thickness of the porcelain had less resistance under cyclic loading. [14] Poor impression recording can also pose problems, especially during fabrication in the dental laboratory[18]. Tensile and Compressive stresses play a major role in the metal ceramic bond. The coefficient of thermal conductivity of the veneering porcelain must not be higher than that of the alloy; this can lead to an increase in tensile stress leading to fracture. [30] Also the veneering porcelain must have high thermal conductivity than the core alloy, as this can also lead to increased tensile stresses causing fracture. [29] A good material must have good fracture toughness, this can prevent the formation of cracks or chipping ultimately leading to failure. [21] [29]In the laboratory, conventional fabrication requires lot of precise work for a successful restoration. The compressive stress is a property that holds the restoration into one. In a conventional fabrication, the metal coping design must be designed to allow the porcelain to be under compression for sealing the bond with metal. [26] Difference in coefficient of thermal expansion can lead to poor bond between metal and ceramic leading to failure.[31]

Air in the ceramic mix, causing porosities can be a major flaw in fabrication of porcelain reducing its strength.[34] The marginal fit can also lead to poor restorations, as proven in a study that metal ceramic FPD had poor marginal fit than zirconia[8]. Even comparing with all ceramics, metal ceramis had very poor internal fit.[23]For complete successful PFM restorations, the parts also have to be less prone to failures. 100 N loads were applied on various parts of a FPD, with the results that the connector region was the most prone to fracture.[4] The connectors must be thick enough to resist occlusal loading[26]. (3-5mm in posterior and 2.5-4 mm in anterior) Collarless Metal FPD, were found to lead to fracture. [12] Though Collarless FPD could be a solution to some aesthetic problems, distogingival margins of collarless FPD are also one of the reasons for fracture.[13]Various comparisons with all ceramic and zirconia have been done through the years. Veneering porcelain thickness of all ceramic showed more success than metal ceramic. [10] A 5 year study showed that zirconia had better cumulative survival and success rate than metal ceramic.[] Another review found that metal core exposed due to fracture.[36] A 18 year study found most failures were due to cementation and framework failures.[19] A clinical performance study found significant change in surface texture, crown wear[25] and also surface roughness due to high pH in acidic beverages[15]. Other than this Metal ceramics also have a high rate of adhesive fractures. [27][32]. A systematic review stated that Metal ceramic had less technical failures than All ceramics, but this study had no validity.[17]

Analyzing the above details Porcelain Fused to Metal restorations were more prone to technical failures.

Conclusion:

In conclusion, it was found that metal ceramic restorations had more of

technical failures. But, the technical failures per se cannot be stated to be the reason for loss of metal ceramic FPDs, aesthetic and biologic aspects also play a part. The aesthetic and biologic failures could be due to the patient's anatomical features, whereas the outcome of technical adversities can be due to errors in fabrication or any other procedural errors, nevertheless this cannot be true always. These three can be interlinked as seen in many cases.

Another point to be noted is the ascent of computerized fabrication, this can lead to less errors especially, technical errors. But, it won't be a definitive solution too; as every person's oral structure and needs are different. As lifestyles are moving forward equally with the speed of internet, patients research various treatment options and also demand their preferred choice. Patients psychologically tend to disregard Metal Ceramic FPDs, as soon as they hear the word," metal", taking their aesthetic features into consideration. Moreover Zirconia does sound more elegant and is becoming a popular mode of treatment due its high survival rate and other outstanding features. Though metal ceramic FPDs are in fact an excellent treatment option considering its durability and cost efficiency, we must admit that it's losing the race against Zirconia crowns and Implants.

REFERENCE:

1. Friedman M, A 15 year review of porcelain veneer failure-a clinician's observations, Compend Contin Educ Dent, 1998, 625-628
2. Haselton DR, Diaz-Arnold AM, Dunne JT, Shear bond strengths of 2 intraoral porcelain repair systems to porcelain or metal substrates, J Prostho Dent, 2001, 526-531
3. Karl M Fischer H, Graef F, Wichmann MG, Taylor TD, Heckmann SM, Structural changes in ceramic veneered threeunit implant supported restorations as a consequence of static and dynamic loading, Dent Matter 2008, 464-470
4. Motta AB, Pereira LC, da Cunha AR, Duda FP, 2008 April, The influence of the loading mode on the stress distribution on the connector region of metal ceramic and all ceramic fixed partial denture, Journal of Artificial Organs, Wiley Online Library, 283-91
5. Napankangas, Ritva and Raustia, Aune, July 2008, Twenty year follow up of Metal Ceramic Single crowns: A Retrospective Study, The International Journal of Prosthodontics, 21, 307-11.
6. Newsome P, Owen S, Improving your margins, Int Dent SA, 2009, 36-42
7. Richard P.Kinsel, Dongming Lin, 20 May 2009, Retrospective analysis of porcelain failures of metal ceramic crowns and fixed partial dentures supported by 729 implants in 152 patients: Patient-specific and implant-specific predictors of ceramic failure, The Journal of Prosthetic Dentistry, Volume 101, Issue 6, 388-394
8. Gonzalo, Esther, Suarez, Maria J, Serrano, Benjamin, Lozano, Jose F.L, 2009, Comparative Analysis of Two measurement methods for marginal fit in Metal Ceramic and zirconia posterior FPDs, International Journal of Prosthodontics, Vol,22 Issue 4, 374-377
9. Comlekoglu M, Dundar M, Ozcan M, Gungor M, Gokce B, Artunc C, Influence of cervical finish line type on the marginal adaptation of zirconia ceramic crowns, 2009 Sep-Oct, Journal of Operative Dentistry, 586-92
10. Akihiko Shirakura, Heeje Lee, Alessandro Geminiani, Carlo Ercoll, Changyong Feng, The influence of veneering porcelain thickness of all ceramic and metal ceramic crowns on failure resistance after cyclic loading, 2009, The Journal of Prosthetic Dentistry, 119-127
11. Sailer I, Philipp A, Zembic A, Pjetursson BE, Hammerle CH, Zwahlen M, A systematic review of the performance of ceramic and metal implant abutments supporting fixed implant reconstructions, Sep 2009, Clinical Oral Implants Research, 4-31
12. Afroz Shaista, Chand Pooran, A case report on Collarless metal ceramic restorations to obscure the umbrella effect, 2010, Indian Journal of Dental Research, Vol:21, Issue:4, 600-602
13. Sikka Swati, R.Chowdhury, P.S.Patil, Marginal Strength of collarless metal ceramic crown, 2010, International Journal of Dentistry, vol.2010, Article ID 521470, 5 pages
14. Alessandro Geminani, Heeje Lee, Changyong Feng, Carlo Ercoli, The influence of incisal veneering porcelain thickness of two metal ceramic crown systems on failure resistance after cyclic loading, May 2010, The journal of prosthetic dentistry, Volume 103 Issue 5, 275-282
15. Kukiattrakoon B et al, Effect of acidic agents on surface roughness of dental ceramics, Dent Res J, 2011, 6-15
16. Johansson A, Omar R, Carlson GE, Bruxism and prosthetic treatment:a critical review, J Prosthodont Res, 2011, 127-136
17. Layton, Danielle, A critical appraisal of the survival and complication rates of tooth supported all ceramic and metal ceramic fixed dental prostheses: The Application of evidence-based dentistry, 2011, International Journal of Prosthodontics, vol.24, Issue 5, 417-427
18. Boksman L, Optimizing occlusal results for crown and bridge prosthese, Dent Today, 2011, 154-157
19. Napankangas, Ritva, Aune, An 18 year Retrospective analysis of Treatment Outcomes with Metal-Ceramic Fixed Partial Dentures, 2011, International Journal of Prosthodontics, vol.24 Issue 4, 314-319
20. Malhotra N, Acharya SR, Conservative approach for esthetic repair of fractured ceramic facing in ceramic fused to metal crowns:a case series, Compend Contin Educ Dent, 2012, 123-129
21. Sakaguchi RL, Powers Jm, Craig's Rstorative Dental Materials, 13th edition, Philadelphia, Mosby Elsevier, Inc, 2012
22. Peter Briggs, Arijit Ray Chaudhuri, Kewal Shah, Avoiding and managing the failure of conventional crowns and bridges, 2012, Dent Update, 39, 78-84
23. MARTINS, Leandro Moura et al, Internal fit of two all ceramic systems and metal ceramic crowns, April 2012, Journal of Applied Oral Sciences, 235-240
24. Behr, M, Winklhofer, C., Schreier,M. et al, Risk of chipping or facings failure of metal ceramic fixed partial prostheses – a retrospective data record analysis, April 2012, Clinical Oral Investigations, Volume 16, Issue 2, 401-405
25. Josephine Esquivel Upshaw, William Rose, Erica Oliveira, Mark Yang, Arthur E.Clark, Kenneth Anusavice, Randomized, Controlled Clinical Trial of bilayer ceramic and metal ceramic crown perfomaance, 14 September 2012, Volume 22, Issue 3, Journal Of Prosthodontics,
26. Shillingburg HT et al, Fundamentals of fixed Prosthodontics, 4th edition, Illinois, USA, Qunitessence Publishing Co Inc, 2012
27. B.Henriques, D.Soares, F.S.Silva, Microstructure, hardness, corrosion resistance and porcelain shear bond strength comparison between cast and hot pressed CoCrMo alloy for metal ceramic dental restorations, August 2012, Journal of the mechanical behaviour of biomedical materials, Volume 12, 83-92
28. Ignacio Farga-Nionles, Ruben Agustin-Panadero, Juan L. Roman-Rodriguez, Maria Granell-Ruiz, Antonia Fons-Font, Dec 2013, Fractographic study of the behaviour of different ceramic veneers on full coverage crowns in relation to supporting core materials, Journal of Clinical and Experimental Dentistry, 260-266
29. Anusavice KJ, Shen C, Rawls HR, Phillips Science of Dental Materials, 12th edition, St Louis, Missouri, USA, Saunders Elsevier, inc, 2013
30. Shadid RM et al, Porcelain fracture of metal ceramic tooth supported and implant supported restorations: a review, Open Journal of Stomatology, 2013, 411
31. Deepak K, Ahila S, Muthukumar B, Vasanthkumar M, Comparitive evaluation of effect of laser on shear bonf strength of ceramic bonded with two base metal alloys: an in vitro study, Indian J Dent Res, 2013, 610-615
32. Bernd Reitemeier et al, March 2013, A prospective 10 year study of metal ceramic single crowns and fixed dental prosthesis retainers in private practice settings, The Journal of Prosthetic Dentistry, vol 109, issue 3, 149-155
33. Walton, Terry R, The upto 25 year survival and clinical performance of 2340 high gold based metal ceramic single crowns, 2013, International journal of prosthodontics, Vol 26, Issue 2, 151-160
34. Rashid H, The effect of surface roughness on ceramics used in dentistry:a review of literature, Eur J Dent, 2014, 571
35. Behr, Michael, Zeman, Florian, Baitinger, Teresa, Galler, Johanna, Koller, Michael, Handel, Gerhard, Rosentritt, Martin, The clinical performance of porcelain fused to metal precious alloy single crowns: chipping, recurrent caries, periodontitis, and loss of retention, 2014, International Journal of Prosthodontics, Vol 27, Issue 2, 153-160
36. S.Rinke, K.Kramer, R.Burgers, M.Roediger, A practice based clinical evaluation of the survival and success of metal ceramic and zirconia molar crowns: 5 year results, 22 September 2015, Journal of Oral Rehabilitation, Vol 43, Issue 2
37. Ivoclar Vivadent, Are metal ceramic restorations still in style?, 8 November 2016
38. Ayesha Aslam, Danish Azeem Khan, Syed Hammad Hassan, Bilal Ahmed, Ceramic fracture in metal ceramic restorations: The Aetiology, Dent Update, 2017, 44, 448-456