ISSN (Online) : 2455 - 3662
SJIF Impact Factor :3.967

EPRA International Journal of

Multidisciplinary Research

Monthly Peer Reviewed & Indexed
International Online Journal

Volume: 3 Issue: 6 June 2017

Published By :
EPRA Journals

SJIF Impact Factor: 3.967 Volume: 3 | Issue: 6 | June 2017

EPRA International Journal of Multidisciplinary Research (IJMR) ISSN (Online): 2455-3662

ROLE OF COPING DESIGNS AGAINST FRACTURE RESISTANCE OF PORCELAIN IN METAL-PORCELAIN FIXED PARTIAL DENTURE: A REVIEW

Chihargo[1]
[1]Prosthodontics Residency Program,
Faculty of Dentistry,
University of Sumatera Utara,
Medan 20155, Indonesia

Haslinda Z Tamin[2]
[2]Professor in Department of
Prosthodontics,
Faculty of Dentistry,
University of Sumatera Utara,
Medan 20155, Indonesia

ABSTRACT

Introduction: *Metal-porcelain fixed partial denture is still being used because it has high fracture resistance and lower cost. However, in some cases, metal collar on labio-marginal is aesthetically unacceptable to the patient.*

Objective: *This literature review aims to provide an understanding for dentists about coping designs on labio-marginal which can affect the function in terms of fracture resistance and aesthetics to prevent "umbrella effect" phenomenon.*

Discussion: *Metal collar coping design (metal butt-joint) can be seen on labio-marginal aspect. Although metal collar has been modified shorter on marginal, this design has weakness in fracture resistance of porcelain. Hence, metal collarless coping design was developed with metal layer on labial, but this design still can not enhance marginal aesthetics. This can be prevented by modifying metal collarless coping design 1-3 mm shorter on labial, which was known as porcelain butt-joint. However, this design has weakness on its loss of ferrule effect.*

Conclusion: *Coping designs of metal collar and collarless also their modifications have its own advantages and weaknesses. Therefore, communication between dentists and laboratory technicians is very important, also the necessary understanding in physical characteristics of materials, design guidelines, and fabrication of metal-porcelain restoration to exploit their strengths and compensate their weaknesses.*

KEY WORDS: fixed partial denture, metal-porcelain restoration, fracture resistance, coping designs

INTRODUCTION

Metal-porcelain Fixed Partial Denture (FPD) is still widely used for anterior aesthetic zone, Although various types of aesthetic restorations such as all porcelain restoration have been introduced in dentistry. It is because metal-porcelain restoration has higher fracture durability and lower cost compared to other alternative as all-porcelain restoration.[1,2]

One of success rate in metal-porcelain FPD restoration was obtained from the appropriate tooth preparations so that the substructure of the metal can be coated with a layer of porcelain. Therefore, the dark color of the metal can be covered and layers of porcelain (opaque, dentin, enamel) can duplicate the appearance of natural tooth.[3] Beside of tooth preparation design, the success rate of metal-

porcelain restorations also depends on appropriate coping design and thickness of porcelain.

Metal coping design consists of full metal collar (metal butt-joint) which are thin on the labio-marginal area that can produce a good adaptation, but it is not aesthetic unless the full metal collar is placed subgingivally. Full metal collar on the labio-marginal area also is not acceptable to patients. Full metal collar has main disadvantage such as a dark discoloration of the gingiva. This phenomenon is called as "umbrella effect" (Fig. 1), with a characteristic of greyish color on the edge of the gingiva and dark interdental papillae.[1,4,5]

Fig. 1. Characteristic of "umbrella effect" phenomenon .[6]

Full metal collar coping design is rarely used on anterior teeth for some aesthetic reasons.[3] Therefore, full metal collar coping design can be modified shorter on marginal area, but this modified metal collar could distort porcelain layers during firing process of porcelain, so that could affect the fracture resistance of porcelain and marginal fitting of the restoration.[1]

There is full metal collarless coping design to meet the aesthetic demands by replacing the metal collar with porcelain layers on marginal area, but this did not solve problems such as the opaque color that masked the metal showed through on marginal area, especially when the marginal tooth preparation was insufficient.[2] Therefore, full metal collarless coping design was modified by shortening the final edge of metal layer 1-3 mm coronally. This modified metal collarless is known as porcelain butt-joint. However, some studies stated this design has weakness such as loss of ferrule effect of metat collar also might not be able to resist the stress which caused during cementation and mastication.[1,2]

This literature review describes about some metal coping designs of a metal-porcelain restoration which can affect the function in terms of fracture resistance and the aesthetic in terms of prevention of the "umbrella effect". An understanding of this literature review can assist dentists in communication with the laboratory technician in fabricating metal-porcelain restorations in accordance with the desired designs.

METAL-PORCELAIN RESTORATION COMPONENTS

Metal-porcelain restorations consist of two main components, i.e. the outer layer of porcelain and metal coping.[3,7,8]

Porcelain Layers

Porcelain layers which form a metal-porcelain restoration are made up of three layers, such as: opaque porcelain, dentin porcelain nd enamel porcelain. (Fig. 2) Opaque porcelain conceals the metal underneath, initiates the development of the shade, and plays on important role in the development of the bond between the porcelain and the metal. Dentin or body porcelain makes up the bulk of the restoration, providing most of the color, or shade. Enamel or incisal porcelain imparts translucency to the restoration.[7]

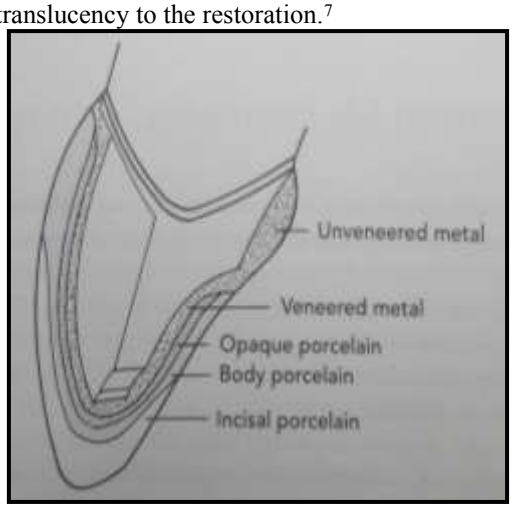

Fig. 2. Layers of metal-porcelain restorations in general.[7]

Metal Coping

Metal coping is a material which is radiopaque and has a high density that serves to support porcelain layers with its mechanically and chemically bonding in forming metal-porcelain restoration.[9]

There are some materials that have been used in fabricating of metal-porcelain restoration, such as: gold alloys (Au), palladium alloys (Pd), titanium (Ti), cobalt-chromium alloys (Co-Cr), nickel-chromium alloys (Ni-Cr).

Gold and palladium alloys can result in porous castings especially if casting buttons / reservoir are reused, are prone to corrosion, and could cause lichenoid reactions. Titanium are well known for its high biocompatibility, but specialized casting required with an argon arc under vacuum, also the manufacture cost is expensive.[10]

Since the introduction of Ni-Cr alloys and Co-Cr alloys for metal-porcelain restorations, numerous claims have been made on the potential for improved coping and

framework designs based on the higher elasticity modulus of these alloys.[11] Co-Cr alloys can be a cost-cutting alternative by the modification of existing noble metal alloys, unfortunately the use of this metal could cause dark oxide formation and poor high-temperature strength.[7]

There are some problems on using Ni-Cr alloys include excessive oxide formation, difficulty in finishing and polishing, and causes contact dermatitis on some patients. However, Ni-Cr alloys are the most commonly metal alloys that have been used due to its low cost, increased strength and hardness, high fusion temperatures, and greater resistance to distortion during porcelain firing.[7,10]

Metal Coping Designs on Labio-Marginal

Marginal adaptation is essential in long-term clinical success on both FPD and the prognosis of the restored abutments.[12-15] Several *in vitro* studies demonstrated that the marginal adaptation of metal-porcelain FPD is influenced by the type of cervical finish line, shrinkage after firing procedures of the veneering porcelain, differences in thermal expansion coefficients of the framework and veneering porcelain and the amount of circumferential porcelain thickness of the substructure. However, the results on the effect of finish line designs on the marginal discrepancies are controversial in the dental literature. Others reported that the shoulder type of preparation had less marginal distortion than the chamfer type after repreated porcelain firings.[13] Finishing line designs on the marginal could also affect metal coping designs on labio-marginal area of metal-porcelain restoration..

Traditionally, metal coping designs on labio-marginal of metal-porcelain restoration have some types such as : metal collar and collarless coping designs and theirs modifications (Fig. 3).

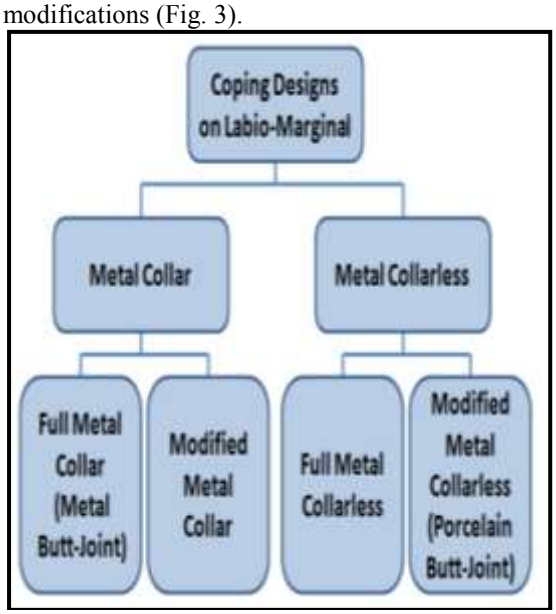

Fig. 3. Schematic distribution of metal-porcelain coping design on Labio-marginal areas.

Full Metal Collar Coping Design

Full metal collar coping design can be called as metal-butt joint. Ths full metal collar serves as a truss that strengthens the casting and overlying porcelain material and enables it to resist deformation during the porcelain firing cycles.[16] (Fig. 4a)

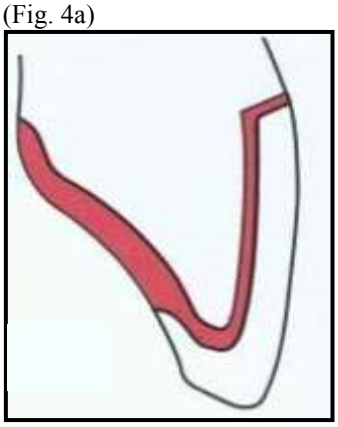

Fig. 4a. Full metal collar coping design.[3]

Therefore, this design produces a very well adaptation on marginal area, but this design is rarely used on anterior teeth for aesthetic reasons, unless the finishing line of tooth preparation on marginal are made below the gingival margin (subgingivally), so that the metal collar can be hidden under margin gingiva. However, this often causes discoloration or dark gray lines which is clearly visible on the gingiva in case of gingival recession, this becoming a main disadvantage of this design.[2,3]

Modified Metal Collar Coping Design

In an attempt to satisfy the aesthetical demands of the patient and maintain the health of the periodontium, clinician's modified the margin of the metal-porcelain restoration by shorten the metal collar on marginal area the facial collar of metal significantly in order to visually eliminate it.[1] (Fig. 4b)

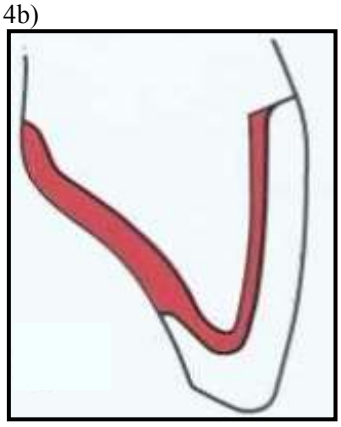

Fig. 4b. Modified metal collar coping design.[3]

But Donovan and Prince (cited from Fahmy, 2012) found that these margins could

distort when the porcelain was fired which is greatly compromising the fit of the restoration and also could lead to fracture of porcelain.[1,18]

Preston (cited from Fahmy, 2012) covered the metal collar on marginal area with porcelain in an attempt to hide it visually. This modification can not be done without over contouring the restoration, especially in cases where the gingival of the anterior tooth was a thin scalloped type. This could lead to gingival irritation.[1,2,6]

Full Metal Collarless Coping Design

Full metal collarless coping design with a thin metal on labial area which is covered by opaque and body porcelain. This design could reduced plaque retention due to highly glazed body porcelain on marginal area. Periodontal health is further promoted by minimal extension of marginal finishing line into the gingival sulcus, without encroaching on biological width, because it is not necessary to hide the metal collar on marginal area.[1,5,6,19] (Fig. 4c)

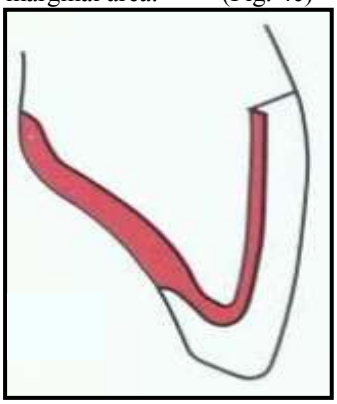

Fig. 4c. Full metal collarless coping design.[3]

Although porcelain layers have been used to occupy the metal collar on marginal area, it is still unable to resolve problems such as opaque porcelain are less able to distribute the transmission of light to enhance the aesthetic in marginal areas, especially when the tooth preparation on the cervical is insufficient, so the murky color from opaque porcelain still can not be covered by the color of body porcelain on marginal area.[2,6,17] Therefore, there is an alternatve design such as modified metal collarless coping design.

Modified Metal Collarless Coping Design

This design is achieved by shorten the edge of metal coping 1-3 mm on labial area.[2,18] (Fig. 4d) This design will increase light transmission to the adjacent root structure.[2] it is due to the increased thickness of porcelain layers by body and enamel porcelain on marginal area.

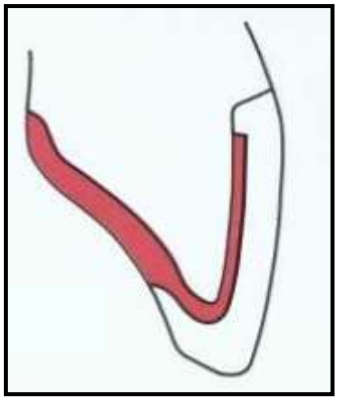

Fig. 4d. Modified metal collarless coping design.[3]

Plaque retention is also decreased due to highly glazed porcelain on marginal area compared to full metal collar coping design with highly polished metal. Therefore, it could be assumed this design is combine the strength of the metal-porcelain restoration with the aesthetics of the full-porcelain restoration on marginal area.[1,6]

However, this concept design has some weakness such as difficulties during fabrication, extra laboratory steps that require more time and more costly, marginal adaptation is not as good as that full metal collar due to loss of ferrule effect from metal collar on marginal. This also could have chances on fracture of unsupported porcelain by metal coping on marginal area during cementation or mastication.[1,2,6]

Nonetheless, several studies showed this modified metal collarless coping design had sufficient fracture strength to endure the maximum human incisive biting force**,** and it was suggested that 1 mm of unsupported marginal shoulder porcelain could be used safely in clinical situations.[2]

Fracture Resistance of Porcelain

Thickness of the coping and the porcelain layering should be considered to prevent mechanical failure of the restoration. [20] Several investigators demonstrated that the fracture of porcelain is not an uncommon problem in clinical practice and may cause the premature failure of FPD. Bragger et al. (cited from Shadid et al., 2013) found that there is an interrelation between porcelain fracture and the long-term survival of FPD. The event of porcelain fracture can increase the risk for the suprastructure to become a failure at 10 years compared to a suprastructure with no porcelain fracture. Walton et al. (cited from Shadid et al., 2013) found that the incidence of porcelain fracture was the second most common cause of metal-porcelain FPD replacement, accounting for 72 (16%) of 451 failed restorations. They also found that porcelain fracture was the most common cause of failure with single crown restorations. This is in agreement with another 7-

year follow-up study from Strub et al. (cited from Shadid et al.,2013) who found that porcelain fracture was the most common cause of failure in metal-porcelain restoration.[21]

Plasmans et al. dan Karn et al. (cited from Danappanavar et al., 2011) recommended that load applied was at an angle of 45° to the incisal edge. (Fig. 5). This simulated the class I Angle normal occlusion in the average adult. The load applied was kept midway between the incisal porcelain build-up on the palatal surface to stimulate the contact of the lower incisor.[22]

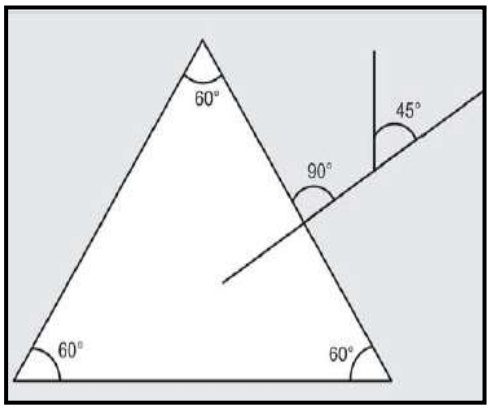

Fig. 5. Load application on anterior tooth.[22]

DISCUSSION

Metal-porcelain restorations have a weakness from the viewpoint of aesthetics in anterior teeth which were right on the aesthetic zone, such as full metal collar coping design that can be seen on the labial aspect. Although metal collar was modified to be shorter, but this design can still cause a bluish gray on gingival tissue, such as cyanosis overview of the gingiva. There are other alternatives of coping designs on labio-marginal of metal-porcelain restorations, ie metal-porcelain restoration without metal collar on marginal area, which is known as metal-porcelain restoration collarless.[1,2,6,16,18,19] This type of restoration is covered by porcelain with shoulder shaped on labio-marginal and reinforced by metal almost the entire surface of the crown, yet still be able to retain the aesthetic qualities and physiological contour on labio-marginal area.[16]

Several investigators demonstrated that the fracture of porcelain is not an uncommon problem in clinical practice and may cause the premature failure of FPD.[21] Waltimo et al. (cited from Yoon et al., 2010) the mean maximum incising force of anterior teeth was 263 N for men and 243 N for women. Kiliaridis et al. (cited from Yoon et al., 2010) reported that physiological maximum incisive biting forces might vary up to 290 N, primarily depended on facial morphology and age. Kheradmandan et al. (cited from Yoon et al., 2010) reported metal-porcelain FPD with modified metal collarless coping design that has 2 mm gap on labial area and also had experienced thermocycling and cyclic loading, could withstand the fracture test better than other full-porcelain FPD. In that report, 100% of the collarless metal-ceramic FPD survived a simulation of five years of mastication in the oral environment.[2]

Research conducted by Yoon et al. (2010) with modified metal collarless coping design on anterior bridge crowns has a higher fracture resistance than the maximum incisal pressure reported in previous studies. Based on these results, they suggested that modified metal collarless coping design which was shortened 2 mm on the labial area can be used on natural teeth, also with acceptable of marginal adaptation, and has been cemented on the prepared teeth without porcelain fracture.[2]

Vernekar et al. (2011) reported that modified metal collarless coping design with the metal collar reduction of 0,5 mm and 1 mm on labial area showed higher fracture resistance than the metal collar reduction of 1,5 mm on labial area, but definitely less significant comparing to full metal collar coping design.[18]

Naina et al. (cited from Fahmy, 2012) stated that in addition to the good results of marginal adaptation of collarless metal-porcelain restoration, modified metal collarless coping design should be made 0.5 mm and 1 mm above on the labial area. The results showed that the maximum fracture load given on the specimen is higher than the natural tooth occlusal forces, so modified metal collarless coping design is recommended by shortening the metal 0.5 mm and 1 mm on labial area. Research by Fahmy (2012) which used modified metal collarless coping design 1.5 mm above the cavosurface angle also have better marginal adaptation than the two types of full-porcelain restorations.[1]

It is important to recognize that any in vitro study design that aims to reproduce a complex biomechanical environment, such as that of mastication, has certain limitations, and the results must be interpreted with caution. For example, the present unidirectional cyclic loading design reproduced only 1 (vertical) vector of forces generally found in the masticatory cycle, and, therefore, does not entirely simulate the complexity of the oral biomechanical environment.[20]

CONCLUSION

In accordance with some of the literatures that have been published, it can be concluded that the coping design of metal collar and collarless and their modifications on labio-marginal area has its advantages and its own weaknesses which can affect the success of a metal-porcelain restoration in terms of function (fracture resistance) and in terms of aesthetic.

Fracture resistance of a metal-porcelain restorations can be affected by various factors.

These factors relating to communication between dentists and laboratory technicians in producing the design of a restoration which has been required, so that the necessary understanding of the physical characteristics of a material and design guidelines and manufacturing a metal-porcelain restorations in order to take the advantage of its strengths and compensate for its weaknesses.

REFERENCE

1. *Fahmy AM. Comparison of marginal fit between collarless metal ceramic and two all ceramic restorations. J American Sci. 2012;8(6):778–82.*
2. *Yoon JW, Kim SH, Lee JB, Han JS, Yang JH. A study on the fracture strength of collarless metal-ceramic fixed partial dentures. J Adv Prosthodont. 2010;2(4):134–41.*
3. *Rosenstiel SF, Land MF, Fujimoto J. Contemporary fixed prosthodontics. 4th ed. St. Louis: Mosby Elsevier; 2006.*
4. *Oh J, Song K, Ahn S, Park J, Lee M, Seo J. Effects of core characters and veneering technique on biaxial flexural strength in porcelain fused to metal and porcelain veneered zirconia. J Adv Prosthodont. 2015;7(5):349–57.*
5. *Chatterjee U. Margin designs for esthetic restoration : an overview. J Adv Oral Res. 2012;3(1):7–12.*
6. *Afroz S, Pooran C. Collarless metal ceramic restorations to obscure the umbrella effect. Indian J of Dent Res. 2010;21(4), pp. 600-602.*
7. *Shillingburg HT, Sather DA, Wilson EL, Cain JR, Mitchell DL, Blanco LJ, Kessler JC. Fundamental of fixed prosthodontics. 4th ed. Chicago: Quintessence Publishing Co Inc;2012.*
8. *O'Brien WJ. Text book of dental material and their selection. 3rd ed. Chicago: Quintessence Publishing Co Inc; 2012. p. 345-381.*
9. *Sinamo, S. Influence of opaque and dentin layer thickness to colour matching in metal ceramic crown. Thesis. 2015.*
10. *Wassell RW, Walls AWG, Steele JG. Crowns and extra-coronal restorations: materials selection. British Dent J. 2002;192(4):199–211.*
11. *Anusavice KJ, Hojjatie B, Dehoff PH. Influence of metal thickness on stress distribution in metal-ceramic crowns. J Dent Res. 1986;65(9):1173–8.*
12. *Singh K, Gupta N, Chowdhary N, Kapoor V. Effect of tooth preparation and poorly designed artificial crowns on health of periodontium and esthetics: a case report. J Pharm Biomed Sci. 2012;24(24):12-15.*
13. *Comlekoglu M, Dundar M, Özcan M, Gungor M, Gokce B, Artune C. Influence of cervical finish line type on the marginal adaptation of zirconia ceramic crowns. J Oper Dent. 2009;34(5):586-592.*
14. *Amini P, Abaslo A. Effect of preparation design on marginal gap of metal-ceramic restorations. J Med Sci. 2009;8(7):665-668.*
15. *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;9(2):17–24.*
16. *Bulbule N, Motwani BK. Comparative study of fracture resistance of porcelain in metal ceramic restorations by using different metal coping designs: an in vitro study. J Clin Diagnostic Res. 2014;8(11):123–7.*
17. *Raptis N V, Michalakis KX, Hirayama H. Optical behavior of current ceramic systems. Int J Periodontics Restorative Dent. 2006;26(1):31–41.*
18. *Vernekar NV, Jagadish PK, Diwakar S, Nadgir R, Krishnarao MR. Alternate metal framework designs for the metal ceramic prosthesis to enhance the esthetics. J Adv Prosthodont. 2011;3(3):113-8.*
19. *Swati S, Chowdhary R, Patil PS. Marginal strength of collarless metal ceramic crown. Int J Dent. 2010.*
20. *Shirakura A, Lee H, Geminiani A, Ercoli C, Feng C. The influence of veneering porcelain thickness of all-ceramic and metal ceramic crowns on failure resistance after cyclic loading. J Prosthet Dent. J Prosthet Dent. 2009;101(2):119–27.*
21. *Shadid RM, Sadaqah NR, Abu-naba L, Al-omari WM. Porcelain fracture of metal-ceramic tooth-supported and implant-supported restorations : a review. Open J Stomatol. 2013;13(11):411–8.*
22. *Danappanavar PM, Nanda Z, Bhaskar M, Gowd V, Molugu M, Reddy KA, et al. Comparative evaluation of resistance failure in nonprecious metal-ceramic restoration at the incisal edge with varying thickness under different application of load: an in vitro study. J Contemp Dent Pract. 2011;12(6):434–40.*