10.5005/jp-journals-10024-1072
ORIGINAL RESEARCH

the Journal of CONTEMPORARY DENTAL PRACTICE
at www.thejcdp.com

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

Prasanna M Danappanavar, Zinnie Nanda, Mummidi Bhaskar, Vikas Gowd, Mallikarjun Molugu, K Amarendher Reddy Rajiv Kumar Reddy, M Ashwini Kumar

ABSTRACT

Objective: To determine the resistance failure value of non-precious metal-ceramic restorations at the incisal edge with varying thickness under different application of load.

Materials and methods: An Ivorian central incisor was prepared to receive metal-ceramic crown, which was further duplicated, invested, casted and 72 metal dies were fabricated in Co-Cr alloy. Metal dies were relieved with die spacer, lubricated and wax patterns were prepared for metal copings, which were further invested and casted and 72 metal copings were fabricated. The ceramic materials were used for the study *viz*. Vita/VMK, IPSd SIGN, and superporcelain. Ceramic built-up was carried out according to manufacturer instructions. Incisal ceramic built-up was carried out with increasing thickness from 2.00 to 2.5 and 3.00 mm.

Results: A total of 72 samples, prepared for the study, were divided into two groups, i.e. group I (36 samples) and group II (36 samples), as per the direction of application of load. The samples were mounted on acrylic block (6 samples/block). A total 12 acrylic blocks were prepared. All the samples were tested using universal testing machine (MTS/USA). The load was applied with crosshead speed of 5 mm/min.

Conclusion: Fracture resistance was found to be highest for the 2.00 mm and lowest for 3.00 mm incisal ceramic thickness samples regardless of the ceramic material in both groups. There was a gradual decrease in fracture resistance as the incisal ceramic thickness increased from 2.00 to 3.00 mm in all samples. Fracture resistance was marginally higher for incisal ceramic build-up of 3 mm thickness on group II metal copings than on group I copings. Fracture resistance was highest for IPSd SIGN followed by that of Vita/VMK-95 and superporcelain.

Clinical significance: A 3.00 mm incisal ceramic thickness offered greater fracture resistance in comparison to lower values of incisal thickness; IPSd SIGN offered greatest fracture resistance followed by that of Vita/VMK-95 and superporcelain.

Keywords: Resistance failure, Incisal ceramic, Tensile failure.

How to cite this article: Danappanavar PM, Nanda Z, Bhaskar M, Gowd V, Molugu M, Reddy KA, Reddy RK, Kumar MA. 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):434-440.

Source of support: Nil

Conflict of interest: None declared

INTRODUCTION

In the field of ceramic dentistry, metal-ceramic restorations are among the most preferred material by clinicians. In North America, nearly 80% of the full coverage restorations are composed of a ceramic that is fused onto a noble, high noble or a base metal alloy, despite of increasing popularity and success of all ceramic restorations.[1]

Esthetic quality of metal-ceramic restorations are found to be inferior to that of all ceramic restorations, may be due to underlying metal coping and limitation in the thickness of ceramic build-up, particularly at incisal edge. The recommended thickness of ceramic at the incisal edge of coping, should not exceed more than 2 mm.[2] In the limited thickness of ceramic, ceramist have less freedom to incorporate esthetic quality such as translucency and other features.

Therefore, the study was planned with the objective to evaluate the resistance failure of nonprecious metal-ceramic restoration at the incisal edge with increasing thickness of ceramic from 2.00 to 2.5 and 3.00 mm and under different application of load. This study further evaluated the stress bearing capacity of ceramic materials, which was used in the study, e.g. Vita/VMK-95 (Vita), IPSd SIGN (Ivoclar/Vivadent) and superporcelain (Noritake/Japan).

MATERIALS AND METHODS

Fabrications of Metal Dies (Fig. 1)

An Ivorian maxillary central incisor was prepared to receive metal-ceramic crown. Standard preparation was carried out as recommended by Hobo and Schillenburg.[3] The prepared Ivorian tooth was duplicated in silicon mould to fabricate a resin pattern. A total of 72 resin pattern, were prepared, invested to phosphate bonded investment material (Kromokovest) and cast cobalt-chromium alloy. A total 72 metal dies were prepared, which were further divided into two groups, as per the direction of application of load which are described below.

Group I: The samples were so mounted that the load applied was at an angle of 45° on the lingual surface of the sample at a point selected at half the thickness of the incisal ceramic build-up. A total 36 metal dies were used for this group. The group I is further divided into three subgroup, i.e. subgroup A, subgroup B and subgroup C, as per three ceramic materials used for the study, e.g. Vita/VMK-95 (Vita), IPSd SIGN (Ivoclar/Vivadent) and superporcelain (Noritake/Japan). So each subgroup contains four samples (Table 1).

Table 1: Sampling of group I and II

Subgroups	*Ceramic materials*	*Incisal ceramic thickness*		
		2.0 mm	*2.5 mm*	*3.0 mm*
Subgroup A	Vita/VMK	4	4	4
Subgroup B	IPSd SIGN	4	4	4
Subgroup C	Superporcelain	4	4	4

Group II: The samples were so mounted that the load was applied at an angle of 75° on the lingual surface closer to the incisal edge. A total of 36 metal dies were used for this group. The group II is further divided into subgroup, similar to group I.

Fabrication of Nonprecious Metal Copings

Seventy-two dies were coated with two coats of die spacer (25 um). The spacer were kept 2 mm short of the gingival finish line. Dies were lubricated and wax pattern were prepared. The thickness of the wax pattern were kept 0.3 mm and spruing was carried out immediately to minimize distortion. They were invested in phosphate-bonded investment material (supervest) and were cast by using nickel-chromium alloy (Durabond). A total of 72 metal copings were prepared and divided in two groups. Out of 72 copings, 36 were used for group I and rest of the 36 were used for group II (Figs 2 and 3).

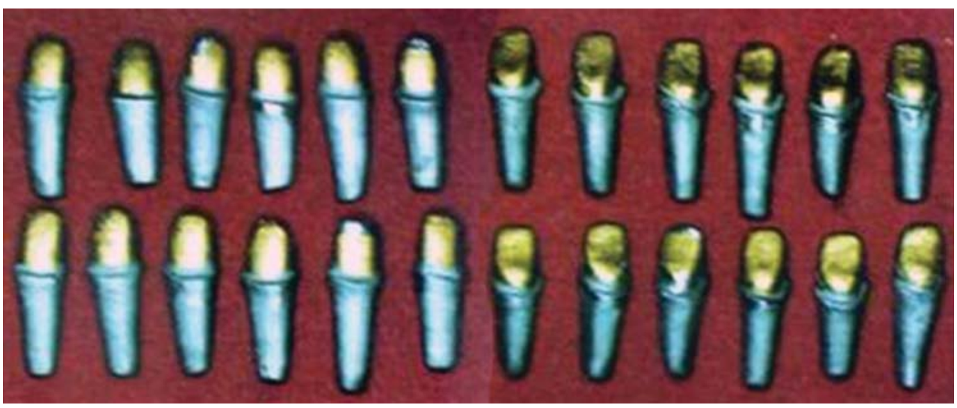

Fig. 1: Metal dies

Fig. 2: Fabrication of nonprecious metal copings

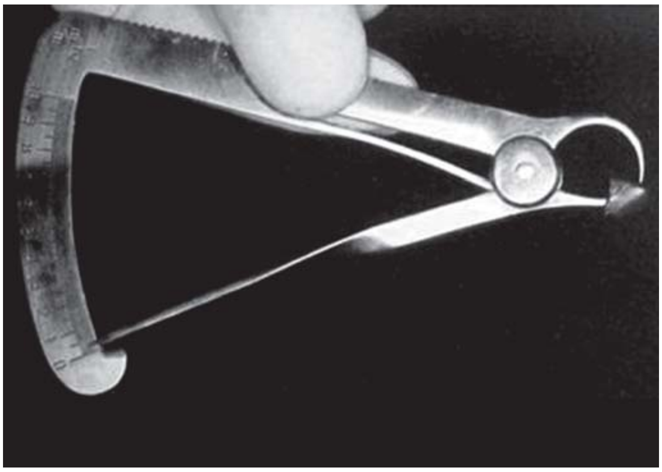

Fig. 3: Thickness of nonprecious metal coping

Ceramic Build-up Procedure (Fig. 4)

Three following ceramic materials were used for the study:

A. Vita/VMK – Vita Germany
B. IPSd SIGN – Ivoclar/Vivadent
C. Superporcelain – Noritake/Japan.

The ceramic build-up procedure and firing of the metal-ceramic crown were carried out according to manufacturers' instructions. Every precaution was taken to minimize the flaw size and porosity to obtain a smooth dense surface.

After the glaze firing, the samples were mounted on 12 acrylic blocks, six samples on each acrylic block. The samples were tested using a Universal testing machine (MTS, USA). The application of load for group I (Fig. 5) samples was carried out in such way that the load was at an angle of 45° to the incisal edge of the crown. This particular angle was selected because it simulated a normal class I occlusion in an average adult (Fig. 6).

In group II, the application of load was carried out in such a way that the load was applied at an angle of 30° on the lingual surface closer to the incisal edge. This particular angle was selected to simulate the lower incisors meeting the upper incisors in a more vertical direction rather than horizontal or angular direction. The application of load was continued until the samples fractured. The peak load required to fracture each of the samples was recorded. The extent and direction of fracture was also noted.

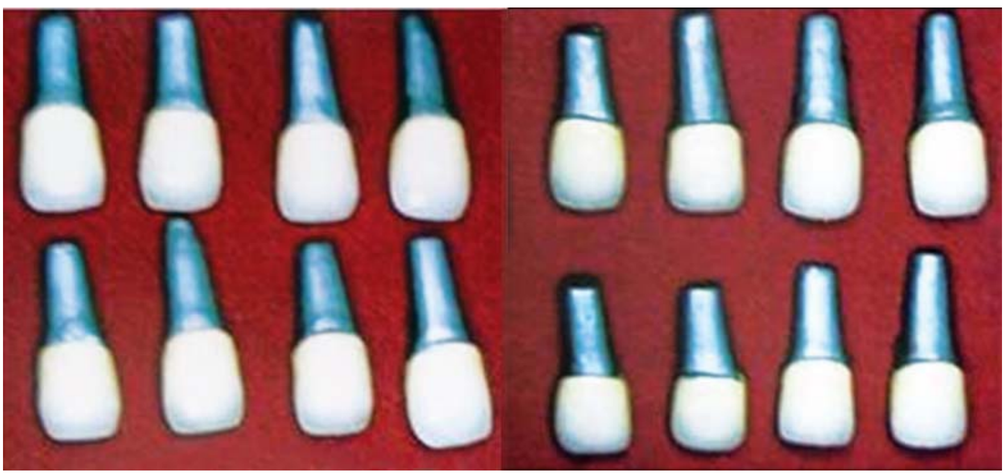

Fig. 4: Ceramic built-up

Fig. 5: Ceramic built-up (3.00 mm)

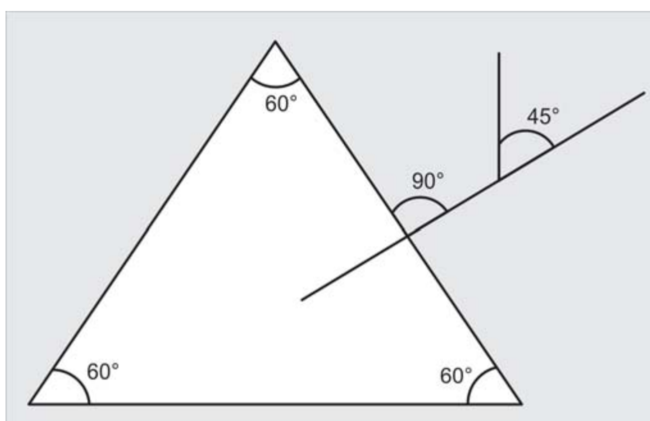

Fig. 6: Load application

RESULTS

The study was carried out to measure the fracture resistance of the incisal ceramic build-up composed of three different ceramic materials of varying thickness on nonprecious (Ni-Cr) and metal copings also of varying thickness. The load at which all the 72 samples fractured was recorded (Tables 2 and 3).

Statistical analysis was carried out using Student's t-test. Statistical comparisons between controls in subgroups A, B and C (2.00 mm, 1st set) and incisal ceramic build-up, i.e. 2.5 and 3.0 mm (2nd and 3rd respectively) in subgroups A, B and C in group I and group II are listed in Tables 4 and 5 respectively. Statistical comparison of incisal ceramic build-up between group II and group I, are listed in Table 6. Statistical comparison between group II and group I was carried out for only incisal ceramic thickness, because values 3 mm incisal ceramic thickness shows statistically significant.

DISCUSSION

In the metal-ceramic restoration, the increase in thickness of ceramic and environment of intraoral stress has adverse relation. Previously, Tucillo JJ and Nelson JP,[4] suggested that increase in the thickness of ceramic would create adverse tensile stress. Cunningham DM and Johnson JF[5] noted that tensile failure in ceramic occurred at approx. 5600 psi, similarly Farah and Craig,[6] observed that minimal tensile failure would occur when vertical load was applied to the tooth, i.e. 980 psi and he further stated that adverse tensile stress of 2400 psi was created when the load was applied 30° to the vertical axis.

Table 2: Group I-resistance failure values (KN)

Ceramic materials	*Incisal ceramic thickness*		
	2.0 mm	*2.5 mm*	*3.00 mm*
Subgroup A Vita/VMK	1.2	0.7	0.5
	0.9	0.8	0.7
	1.6	0.8	0.6
	1.4	0.7	0.6
IPSd SIGN	1.6	0.9	0.7
	1.4	0.9	0.8
	1.4	0.8	0.7
	1.2	1.0	0.7
Superporcelain	0.9	0.8	0.5
	0.8	0.8	0.5
	0.9	0.7	0.5
	1.0	0.7	0.6

Table 3: Group II-resistance failure values (KN)

Ceramic materials	*Incisal ceramic thickness*		
	2.0 mm	*2.5 mm*	*3.00 mm*
Subgroup A Vita/VMK	1.7	0.9	0.7
	1.6	0.8	0.7
	1.6	0.8	0.8
	1.6	0.9	0.7
IPSd SIGN	1.9	1.1	0.9
	1.8	1.1	1.0
	1.8	1.0	0.8
	1.9	1.0	0.8
Superporcelain	1.2	0.9	0.7
	1.0	1.0	0.7
	1.1	0.8	0.6
	1.0	0.8	0.7

Anusavice KJ and Hojjatie B[2] analyzed the stress distribution at the incisal region in a metal-ceramic anterior crown and suggested that when a vertical load of 200 N was applied along the lingual surface near the incisal edge, a maximum tensile stress of 49.2 mpa, was recorded where the incisal ceramic thickness was 4 mm and minimum tensile stress of 46.2 mpa was recorded when the incisal ceramic thickness was 1mm. They further stated that increasing incisal ceramic thickness, by reducing the amount of tooth structure, did not significantly influence the stress distribution in a crown or cememt layer. They also claimed that more severe stress was created when applied load approached a horizontal direction, which does not happen in the oral cavity. Both the studies indicated that orientation of the load was significant rather than thickness of ceramic.

In the oral enviroment, tensile stress is usually created by bending forces acting at the surfaces of the restorations. Maximum tensile stress in a ceramic-metal restoration is calculated along a horizontal plane that lies entirely inside the porcelain and which intersects the lingual surface 0.8 mm above the metal-ceramic junction.[7] When calculating the stress value for incisal ceramic thickness for a metal-ceramic restoration, the recommended depth of the tooth preparation at the incisal edge of anterior teeth is 1.5 to 2.0 mm;[2] the ceramic on the coping should not exceed 2 mm thickness. Although some prosthodontists suggest that there would be increase in tensile stress with the incisal ceramic thickness exceeding 2 mm, they do not state the magnitude of the increase in stress or whether it will lead to fracture of the metal-ceramic restorations in the oral environment.

In the present study, fracture resistance of incisal ceramic of varying thickness ranging from 2.0, 2.5 and 3.0 mm was evaluated on nonprecious metal. 2.00 mm incisal ceramic thickness was kept as control for evaluation of fracture resistance. The metal-ceramic crown samples utilized for the studies were similar to those designed by Anusavice and Hojjate[2] as well as by Farah and Craig[6] and simulate the clinical situation. All the metal-ceramic crowns were cemented to the metal dies with zinc phosphate cement, which has good compressive strength.

Six samples were mounted on each acrylic block. The samples were divided into two groups, i.e. group I and

Table 4: Statistical comparision of the failure resistance values (in KN) in group I (mean ± SD)

Material	*Indices*	*2.00 mm*	*2.5 mm*	*3.00 mm*	*Mean changes from 2.00 mm* *2.5 mm*	 *3.00 mm*
Vita/VMK (n = 4)	x SD range	1.2685 (0.2513) 0.97-1.6	0.7100 (0.0215) 0.66-0.73	0.6025 (0.015) 0.59-0.62	* 0.5575 (0.1523) t = 3.63	* –0.6650 (0.1511) t = 4.40
IPSd SIGN (n = 4)	x SD range	1.602 0.332 1.11-1.8	0.850 0.021 0.62-0.67	0.645 0.021 0.62-0.67	** 0.7525 0.192 t = 3.92	** 0.9575 0.1922 t = 4.98
Superporcelain (Noritake)	x SD range	0.962 0.333 0.92-1.00	0.698 0.013 0.68-0.71	0.595 0.013 0.58-0.61	*** –0.265 0.020 t = 12.99	*** –0.3675 0.0204 t = 18.00

Significant : * p < 0.05, ** p < 0.01, *** p < 0.001

Table 5: Statistical comparision of the failure resistance values (in KN) in group II (mean ± SD)

Material	*Indices*	*2.00 mm*	*2.5 mm*	*3.00 mm*	*Mean changes from 2.00 mm* *2.5 mm*	 *3.00 mm*
Vita/VMK (n = 4)	x SD range	1.3486 (0.3503) 0.98-1.8	0.8500 (0.0383) 0.82-0.90	0.7025 (0.0225) 0.66-0.72	* 0.6623 (0.1833) t = 3.82	* –0.5950 (0.1612) t = 4.86
IPSd SIGN (n = 4)	x SD range	1.7824 0.3817 1.16-1.9	0.9775 (0.0171) 0.96-1.10	0.685 0.026 0.64-0.66	** 0.796 0.199 t = 3.98	** 0.9875 0.1985 t = 4.88
Superporcelain (Noritake)	x SD range	0.989 0.371 0.98-1.1	0.81 (0.0008) 0.80-0.82	0.612 0.017 0.62-0.68	*** –0.245 0.019 t = 11.89	*** –0.3689 0.0215 t = 17.98

Significant: *p < 0.05, ** p < 0.01, *** p < 0.001

Table 6: Statistical comparision of the failure resistance values (in KN) between group II and group I (mean ± SD)

Ceramic material	*Group I*	*Group II*	*Mean difference*	*t-values*	*Significant*
Vita/VMK	(A) 4 0.6025 (+0.015) 0.59-0.62	(A) 4 0.6900 (+0.012) 0.68-0.70	0.875 (+0.0109)	7.99	***
IPSdSIGN	(B) 4 0.6450 (+0.0208) 0.62-0.06	(B) 4 0.7125 (+0.0095) 0.70-0.72	0.0675 (+0.0170)	3.96	**
Superporcelain (Noritake)	(C) 4 0.5950 (+0.0129) 0.58-0.61	(C) 4 0.6250 (+0.0192) 0.60-0.64	0.0300 (+0.0133)	2.25	NS
All together	(A+B+C) 12 0.6142 (+0.0275) 0.58-0.7	(A+B+C) 12 0.6758 (+0.04077)	0.0616 (+0.0148)	4.15	**

NS: Nonsignificant p < 0.05, ** Significant p < 0.01, *** Highly significant p < 0.001

group II as per the direction of load. In the group, load applied was at an angle of 45° to the incisal edge as recommended by Kern et al and Plasmans.[8,9] This simulated the class I occlusion situation in the average adult. The load applied was kept midway between the incisal ceramic build-up on the lingual surface to simulate the contact of the lower incisor. The load applied was at an angle of 75° to the incisal edge, in group II. This particular angel was selected because studies by Anusavice and Hojatie[2] and Farah and Craig,[6] observed that direction of load is very important rather than thickness of ceramic. It was found that maximum tensile failure in ceramic occurred when the direction of load was 30° to the vertical axis. So, this particular angel create more vertical direction rather than horizontal or angular direction. Load on the samples was applied at a crosshead speed of 5 mm/min until the sample fractured. The peak load at which sample fractured was noted. Peak fracture loads of all samples are listed in tables.

The peak loads at which 2.00 mm (1st set) control samples in subgroups A, B and C fractured were 1.2 KN, 1.6 KN and 0.9 KN respectively. In comparison with these control, 2.00 mm samples in all three subgroups, the peak loads for 2.5 and 3.0 mm (2nd and 3rd sets) samples, were found to decrease progressively. Chipping of the incisal ceramic was seen in all subgroups with 2.0 mm incisal ceramic thickness without any sign of clear fracture lines. On the other hand, oblique fracture lines involving the incisal edge were clearly seen within 2 to 3 mm of the facial ceramic in the 2.5 and 3.0 mm samples in all three subgroups of both group I and group II. Hence, this area was considered to be a high tensile stress area. The fracture was in the ceramic material itself, no separation of the ceramic at the metal-ceramic interface was seen. Thus, the fracture was considered a cohesive failure of the ceramic material.

Fracture resistance of subgroup, i.e. IPSd SIGN ceramic samples, was superior to that of subgroup A (Vita/VMK-95) and subgroup C (Superporcelain) samples regardless of the incisal ceramic thickness. This may be due to the inherent strength of the material.[10-15]

When group II was compared with group I for fracture resistance of incisal ceramic thickness of 3 mm, group II samples show marginally higher fracture resistance than group I (nonprecious metal copings).

According to the present study, the fracture resistance of 3.0 mm samples in groups I and II is much higher than the reported biting force in the anterior region, i.e. 20 to 55 lbs (89-111 N).[16,17] This is promising from an esthetic point of view, it is required to build up a maximum incisal ceramic thickness up to 3 mm. The direction of the load has to be evaluated, i.e. the incisal guidance has to be evaluated because when the lower central incisors meet the upper central incisors, the direction of contact of the lower central incisors will be more in favor of the vertical direction rather than in the horizontal direction.[2,6] Similarly, in protrusive contact, the lower central incisors meet the upper central incisors in edge-to-edge contact so that the line of application of force passes through the body of the incisors and creates less movement. Other factors that we considered at the time of preparation were line angles and point angles rounded to minimize concentration of stress. Similarly, at the time of ceramic build-up, precaution was taken to minimize the porosity and obtain a smooth dense surface.[16,17] The thermal coefficient of expansion of metal was slightly higher than the ceramic and the firing cycle was carried out according to manufacturer's instructions.

Most of the dental clinician preferred metal-ceramic restorations, for crown and fixed partial denture, because it is stronger and durable material, more important, it is cost-effective than all ceramic restoration.[18-30] To achieve highest esthetic quality in metal-ceramic restoration needs evaluation of newer material for their biocompatibility, strength and esthetics.

An *in vivo* study is suggested to verify the results of the present *in vitro* study, which has its own limitations. Further studies are required to investigate the load bearing capacity of nonprecious and precious metal copings to resist the fracture of incisal ceramic subject to varied direction and magnitude of load.

CONCLUSION

1. Fracture resistance was found to be highest for the 2.00 mm incisal ceramic thickness samples regardless of the ceramic material in both in group I and group II metal copings.
2. There was a gradual decrease in fracture resistance as the incisal ceramic thickness increased from 2.00 to 3.00 mm in all samples.
3. Fracture resistance was lowest for 3.00 mm incisal ceramic thickness.
4. Fracture resistance was marginally higher for incisal ceramic build-up of 3 mm thickness on group II metal copings than on group I copings.
5. Fracture resistance was highest for IPSd SIGN followed by that of Vita/VMK-95 and superporcelain.

REFERENCES

1. Drescher JD. IPSd SIGN optimizing glass ceramic to metal adhesion for clinical success. Signature 2000;7:11-13.
2. Anusavice KJ, Hojjatie B. Influence of incisal length of ceramic and loading orientation of stress distribution in ceramic crown. J Dent Res 1988;67:1371-75.

3. Hobo S, Shillingburg HT. Porcelain fused to metal: Tooth preparation and coping design. J Prosthet Dent 1973;30:28-36.
4. Tuccillo JJ, Nielsen JP. Shear stress measurement at a dental porcelain-Gold bond interface. J Dent Res 1971;1(2):626-33.
5. Cunningham DM, Johnson JF. The use and construction of gold crown with a fused porcelain veneer: A progress report. J Prostho dent, 1956;(6):811.
6. Farah JW, Craig RG. Distribution of stresses in porcelain-fused-to-metal and porcelain jacket crowns. J Dent Res 1975;54:255-61.
7. Preston JD. Perspectiveness in dental ceramics proceedings of fourth international symposium on ceramics. Quintessence Publishing 1989. p. 175-91.
8. Kern SB, von Fraunhofer JA, Mueninghoff LA. An in vitro comparison of two dowel and core techniques for endodontically treated molars. J Prosthet Dent 1984;51:509-14.
9. Plasmans PJ, Welle PR, Vrijhoef MM. In vitro resistance of composite resin dowel and cores. J Endod 1988;14:300-04.
10. Vence BS. Electroforming technology for galvanoceramic restorations. J Prosthet Dent 1997;74:444-49.
11. Sorensen JA. IPSd SIGN wear characteristics of a new fluorapatite-leucite glass ceramic. Signature 2000;7: 2-4.
12. Winter RR, Cornell DF. IPSd SIGN The philosophy and utilization of glass ceramic for metal. Signature 2000;7:5-10.
13. Gandey RA. IPSd SIGN. The evolution continues. Signature 2000;7:1.
14. Winter RR. IPSd SIGN Parameters for achieving predictable Gingival aesthetics. Signature 2000;7:1.
15. Winter RR. IPSd SIGN Parameters for achieving predictable Gingival aesthetics. Signature 2000;7:15.
16. Skinner, Phillips. Science of dental materials (10th ed). WB Saunders: p. 66.
17. Hammad TA, Talic YF. Design of bond strength tests for metal-ceramic complexes: Review of the literature. J Prosthet Dent 1996;75:602-08.
18. Bagby, Marshall SJ. Metal-ceramic compatibility: A review of literature. J Prostho Dent 1990:63:21-25.
19. Hondrum SO. A review strength properties of dental ceramics. J Prostho Dent 1992;67:859-65.
20. Preston JD. Perspective in dental ceramics proceedings of fourth international symposium of ceramics. Quintessence Publishing 1989:53-64.
21. Campos RE, Soares CJ, Quagliatto PS. In vitro study of fracture load and fracture pattern of ceramic crowns: A finite element and fractography analysis. J Prosthodont Aug 2011;20(6): 447-55.
22. Ellakwa A, Raj T, Deeb S, Ronaghi G, Martin FE, Klineberg. Influence of implant abutment angulations on the fracture resistance of overlaying CAM-milled zirconia single crowns. Aust Dent J Jun 2011;56(2):132-40.
23. De Oliveira JL, Martins LM, Sanada J, de Oliveira PC, do Valle AL. The effect of framework design on fracture resistance of metal-ceramic implant-supported single crowns: Int J Prosthodont Jul-Aug 2010;23(4):350-52.
24. Geminiani A, Lee H, Feng C, Ercoli C. The influence of incisal veneering porcelain thickness of two metal ceramic crown systems on failure resistance after cyclic loading: J Prosthet Dent May 2010;103(5):275-82.
25. Al-Omari WM, Shadid R, Abu-Naba'a L, El Masoud B. Porcelain fracture resistance of screw-retained, cement-retained, and screw-cement-retained implant-supported metal ceramic posterior crowns. Prosthodont Jun 2010;19(4):263-73.
26. Michalakis KX, Stratos A, Hirayama H, Kang K, Touloumi F, Oishi Y. Fracture resistance of metal-ceramic restorations with two different margin designs after exposure to masticatory simulation. J Prosthet Dent Sep 2009;102(3):172-78.
27. Kim S, Kim HI, Brewer JD, Monaco EA Jr. Comparison of fracture resistance of pressable metal-ceramic custom implant abutments with CAD/CAM commercially fabricated zirconia implant abutments. J Prosthet Dent Apr 2009;101(4):226-30.
28. AL-Makramani BM, Razak AA, Abu-Hassan MI. Evaluation of load at fracture of Procera AllCeram copings using different luting cements. J Prosthodont Feb 2008;17(2):120-24. Epub 2007 Nov 28.
29. Salameh Z, Sorrentino R, Ounsi HF, Goracci C, Tashkandi E, Tay FR, Ferrari M. Effect of different all-ceramic crown system on fracture resistance and failure pattern of endodontically treated maxillary premolars restored with and without glass fiber posts. J Endod Jul 2007; 33(7):848-51. Epub 2007 Mar 26.
30. Ghazy MH, Madina MM.:Fracture resistance of metal- and galvano-ceramic crowns cemented with different luting cements: in vitro comparative study. Int J Prosthodont Nov-Dec 2006;19(6):610-12.

ABOUT THE AUTHORS

Prasanna M Danappanavar

Professor and Head, Department of Oral Pathology, MNR Dental College and Hospital, Sangareddy, Andhra Pradesh, India

Zinnie Nanda

Professor, Department of Conservative Dentistry, ACPM Dental College, Dhule, Maharashtra, India

Mummidi Bhaskar

Professor, Department of Orthodontics, Vishnu Dental College Bhimavaram, Andhra Pradesh, India

Vikas Gowd

Professor, Department of Prosthodontics, Meghna Institute of Dental Sciences, Nizamabad, Andhra Pradesh, India

Mallikarjun Molugu

Professor, Department of Prosthodontics, Meghna Institute of Dental Sciences, Nizamabad, Andhra Pradesh, India

K Amarendher Reddy

Professor, Department of Conservative Dentistry, Pullareddy Dental College, Kurnool, Andhra Pradesh, India

Rajiv Kumar Reddy

Professor, Department of Prosthodontics, Pullareddy Dental College Kurnool, Andhra Pradesh, India

M Ashwini Kumar (Corresponding Author)

Professor, Department of Oral Medicine and Radiology, MNR Dental College and Hospital, Sangareddy-502294, Andhra Pradesh, India Phone: 9440061246, e-mail: drashwin@dr32teeth.com