ORIGINAL RESEARCH

Comparison of Fracture Resistance of Cast Post and Core using Different Alloys: An Unexplored Frontier

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ABSTRACT

Aim: To evaluate and compare the failure threshold of custom cast post and core using different alloys available in Indian market.

Materials and methods: A maxillary typodont central incisor was reduced to a height of 2 mm above CEJ and post space of 10 mm was prepared leaving 4 mm from apex. This was cast in stainless steel (SS) and 24 samples were prepared using auto-polymerizing acrylic resin which was divided in four groups of 6 each. Each group was cast using separate alloy. Group 1: Gold alloy, groups 2 and 3: Commonly marketed technique alloys-noble gold dental alloy and kesho alloy and group 4: Base metal alloy. The samples were loaded at 135º using universal testing machine and failure thresholds were recorded and their means were calculated.

Statistical analysis used: Analysis of variance and student t-test.

Results: The mean values recorded were highest for group D followed by groups A, C and lowest for B. All the groups showed significant differences for the failure threshold tested. Groups B and C showed less failure threshold than the other two groups but much higher than the average masticatory load.

Conclusion: Technique alloys can be used as a cheap alternative to the conventional alloys when used for fabrication of custom cast posts in terms of failure threshold.

Keywords: Autopolymerizing resin, Base metal, Failure threshold, Technique alloy.

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INTRODUCTION

Management of badly broken tooth with pulpal involvement presets challenges both on endodontic as well as prosthodontic aspects. Decisions regarding need of post, type of post and materials to be used for post have been debatable since long time. Some authors suggest that dentin in endodontically treated teeth undergoes change in collagen cross-linking thus making them brittle and susceptible to fracture.[1] Guntmann JL[2] stated loss of structural integrity associated with access preparation leading to high fracture rates in endodontically treated teeth.

The concept of endodontic post came to light by Pierre Fauchard around 200 years ago.[3] Later, Richmond and Davis crowns fitted in canals were used for restoration of pulpless teeth.[4] Since then, numerous methods as well as materials have been advocated for the fabrication of post and core varying from conventional cast post and core to prefabricated posts and amalgam or composite as core. A success rate of 90.6% has been reported by a 6 years retrospective study using cast post and cores.[5]

Custom fabricated post and core in gold alloy has been used for decades as a foundation restoration to support the final restoration.[6-8] In 1971, Gold became a freely traded commodity due to abduction of 'The Gold Standard' by United States.[9] As a result, prices of gold and other precious alloys soared high in market. To meet the demand at a cost-effective price, variety of alloys were marketed under different brand names creating an added challenge to the entire profession.

Thorough knowledge of dentinal properties is essential to suggest a material to be fit for the specific function it has to perform. Thus, the present study has been contemplated to evaluate and compare the failure threshold of custom cast post and core using different alloys available in Indian market.

The null hypothesis was that no difference exists between alloys when compared for failure threshold.

MATERIALS AND METHODS

A typodont maxillary central incisor was reduced 1.5 mm facially with a shoulder finish line and 0.5 mm lingually using chamfer finish line. The coronal region of the tooth was reduced to a height of 2 mm above the cemento-enamel junction in order to simulate clinical situations. Post space of 10 mm depth was prepared using peaso-reamers leaving 4 mm from the apex. An antirotational groove of 0.6 mm was also prepared lingually allowing complete and uniform seating of prepared resin patterns.

The reduced tooth was cast in stainless steel (SS) and was used as master die for the study (Fig. 1). The patterns were fabricated of autopolymerizing acrylic resin using direct method and petroleum jelly was used as a lubricant before fabrication of each pattern.

Twenty-four patterns were prepared, sprued with 12 gauge sprue wax at an angle of 45° and were divided in 4 groups having 6 each (Table 1 and Fig. 2).

The patterns to be cast in gold, noble-gold dental alloy and kesho alloys were invested in gypsum bonded investments and casted in centrifugal type of casting machine where as those to be cast in Remanium G-soft alloy were invested in phosphate bonded investment and casted in induction casting machine as per manufacturer guidelines. Castings were allowed to cool and sprues were cut using separating disks. Patterns casted in Remanium G-soft alloy group were sandblasted and patterns of other groups were pickled with 50% hydrochloric acid. (Figs 3 and 4).

Fig. 1: Stainless steel jig along with die

The die was mounted in a SS jig specifically prepared for the purpose of loading of post and core at an angle of 135° to the long-axis.

INVESTIGATION OF THE STUDY

All the samples were stored in distilled water at 37°C for 24 hours to simulate intraoral conditions. Each sample was placed on the jig and subjected to thermocycling of 4000 cycles with 30 seconds intervals. A compressive load was applied using universal testing machine with cross head speed of 5 mm/minute until failure thresholds were noted. Mean was calculated and data was analyzed using SPSS software (Figs 5 and 6).

RESULTS

The failure loads of all the samples were recorded. The failure loads were highest for Remanium G-soft alloy group (Gp-D) in the range of 740 to 810 kg followed by gold group (Gp-A), Kesho alloy group (Gp-C) and least for Noble-gold dental alloy (Gp-B) (Table 2).

The mean values were found to be highest for group-D-779.67 kg whereas lowest values were recorded for group-B—105.33 kg and for groups A and C, the values were 421.00 and 151.33 kg respectively (Table 3).

Analysis of variance states inter-group degree of freedom of 3 giving a fisher test value of 1558.48 which reveals significant differences in fracture loads among different alloy groups (Table 4).

Table 1: Distribution of samples in 4 groups

Groups	*Number of samples*	*Contents*
A	6	Post and cores cast in gold alloy type III.
B	6	Post and cores cast in noble golden-dental alloy
C	6	Post and cores cast in kesho alloy
D	6	Post and cores cast in remanium G-soft alloy

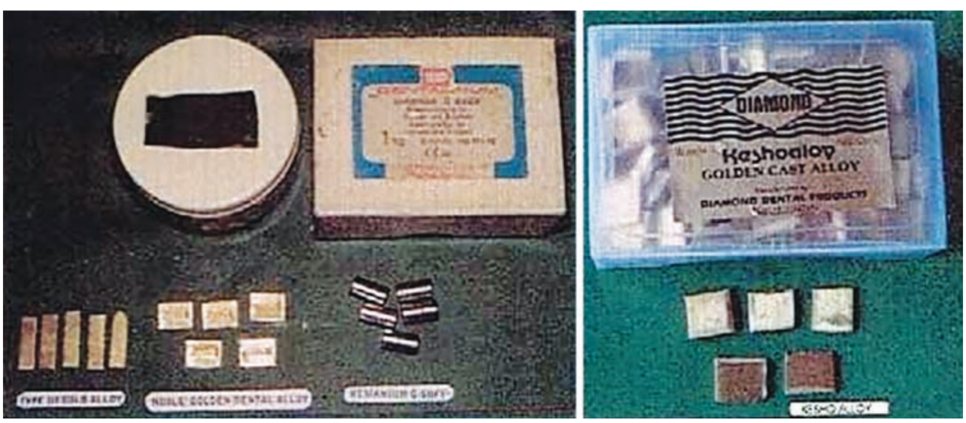

Fig. 2: Alloys used

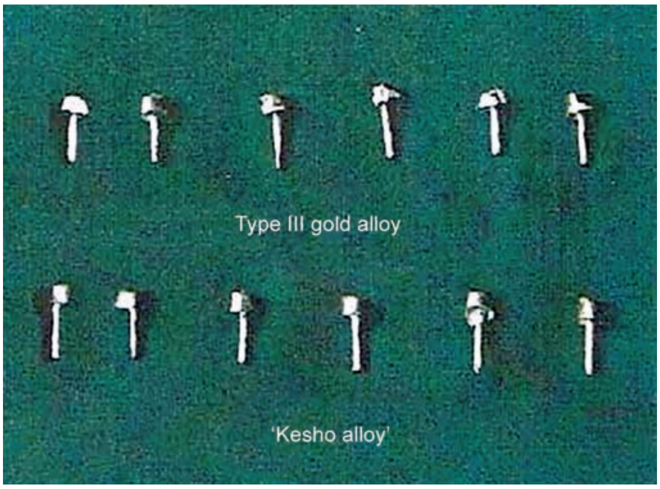

Fig. 3: Custom cast posts of groups A and C

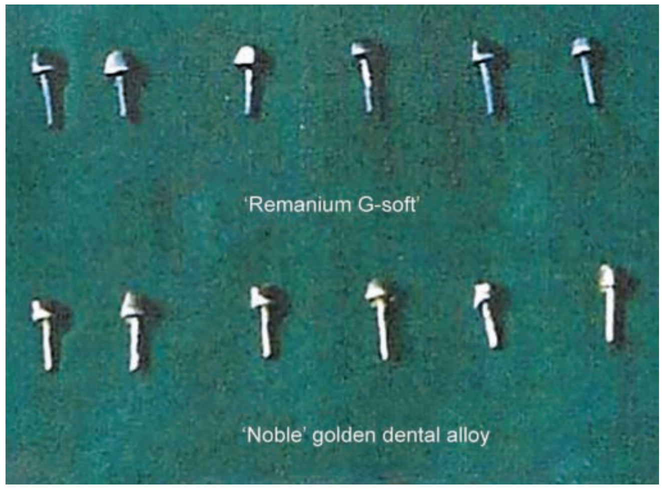

Fig. 4: Custom cast posts of groups D and B

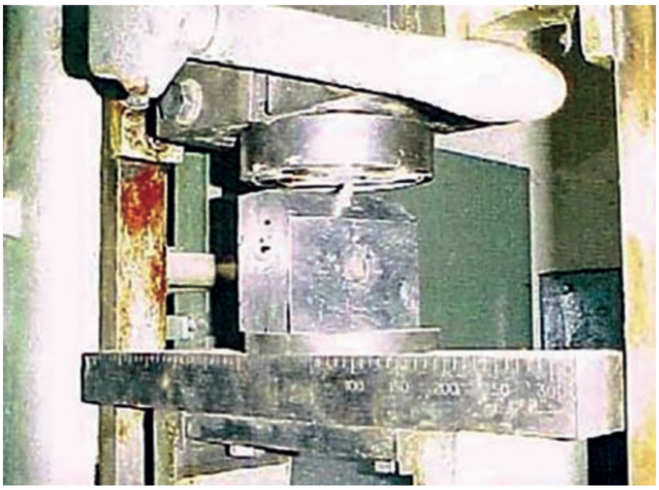

Fig. 5: Method of testing of sample

Fig. 6: Failure of the samples

Group comparisons of failure loads between groups A with B, C and D reveals student t-test value (t) of 31.300, 27.2807 and 24.31143 respectively with a probability factor of < 0.001. This signifies that significant differences exist between all the groups when compared with group A (Tables 5 to 7).

Comparison of group B with groups C and D reveals student t-test value (t) of 8.5584 and 55.2765 respectively with a probability factor of < 0.001 suggesting significant differences between groups B and C and highly significant between groups B and D (Tables 8 and 9).

Table 2: Failure loads of different alloys in kilograms

	Alloys			
S. No.	*Group A*	*Group B*	*Group C*	*Group D*
1	450	120	166	760
2	390	94	148	740
3	408	102	140	818
4	410	108	152	772
5	426	96	148	788
6	442	112	154	800

Comparison of groups C with D has a student t-test value (t) of 52.212 suggesting significantly higher values for group D (Table 10).

DISCUSSION

Mutilated endodontically treated teeth can be restored best with the help of posts. The inclination toward the conservative approaches leads us to prefer substantially custom cast posts over prefabricated ones. Gold alloy has been a traditional material for fabrication of custom cast post and cores. Cast gold alloy (type III or IV) is an inert material with modulus of elasticity (14.5×10^6 psi) and

Table 3: Analysis of failure loads

	Group A	*Group B*	*Group C*	*Group D*
N	*6*	*6*	*6*	*6*
Mean (in kg)	421.00	105.33	151.33	779.67
SD	22.62	9.93	8.64	28.18
SE	9.2320	4.053	3.53	11.50
Range	390–450	94–120	140–166	740–818

N: Number of samples; SD: Standard deviation; SE: Standard error

Table 4: Analysis of variance in different alloys

Sources of variation	*Degree of freedom*	*Sum of square*	*Mean sum of square*	*f-ratio*
Between the groups	3	1728977.333	576325.778	f = 1558.48 p = 1*10-13
Error	20	7396.000	369.800	
Total	23	1736373.333		

f: Fisher test value; p: Probability factor

Table 5: Comparison of groups A with B

	Group A	*Group B*
N	6	6
Mean (in kg)	421.00	105.33
SD	22.62	9.93

T: 31.3000; p < 0.001

Table 6: Comparison of groups A with C

	Group A	*Group C*
N	6	6
Mean (in kg)	421.00	151.33
SD	22.62	8.64

T: 27.2807; p < 0.001; t: Students t-test; p: Probability factor

Table 7: Comparison of group A with group D

	Group A	*Group D*
N	6	6
Mean (in kg)	421.00	779.67
SD	22.62	28.18

T: 24.3114; p < 0.001; t: Students t-test; p: Probability factor

Table 8: Comparison of group B with group C

	Group B	*Group C*
N	6	6
Mean (in kg)	105.33	151.33
SD	9.93	8.64

T: 8.5584; p < 0.001; t: Students t-test; p: Probability factor

Table 9: Comparison of group B with group D

	Group B	*Group D*
N	6	6
Mean (in kg)	105.33	779.67
SD	9.93	28.18

T: 55.2765; p < 0.001; t: Students t-test; p: Probability factor

Table 10: Comparison of group C with group D

	Group C	*Group D*
N	6	6
Mean (in kg)	151.33	779.67
SD	8.64	28.18

T: 52.2123; p < 0.001; t: Students t-test; p: Probability factor

coefficient of thermal expansion (15×10^{-6}C) similar to that of enamel, and yet has good compressive strength to withstand normal occlusal forces.[6] But, due to the inflation in rates of gold, other substitutes have to be explored. Base metal alloys are there in market but their high hardness values leading to lack of adjustments may predispose the tooth to root fracture.[6]

The aim of this study was to evaluate and compare the fracture resistance of posts fabricated using different alloys, two of which, being the most economical. The two alloys included in the study are basically the technique alloys used in laboratories and for educational purposes. The reason for their comparison with standard alloys is to consider them as an alternative, especially for patients belonging to poor socioeconomic strata. These two alloys imitate gold alloy in color but have no amount of gold as their constituent. These alloys are basically copper based limiting their use only for post and core, since the same is never exposed to oral environment and remains embedded in final crown thus minimizing the fear of corrosion and toxicity.

Maxillary central incisor was selected for the study as it is the most vulnerable tooth to trauma because of its position, being in front.[10] Also, less tooth structure and small pulp chamber adds to the increased cases of post placement in incisors.[6] Master die was fabricated in stainless steel[9] utilizing the typodont so as to bear the heavy amount of loads the samples would be subjected to and to standardize the length as well as width of the prepared posts. The patterns were prepared using auto-polymerizing resin as it is easy to use with more body as compared to wax. The cast samples were dipped in distilled water at 37ºC for 24 hours and thermocycling was carried out with the objective of simulating intraoral conditions. The cast samples placed on jig were embedded intentionally to load them at an angle of 130º to the long-axis as an attempt to simulate contact angle found between maxillary and mandibular anteriors in class I occlusion.[11,12] Readings were recorded when the samples got deformed or fractured and mean values were calculated.

The failure threshold found in descending order was as:

Group D (Ni-Cr) > group A (Gold alloy type III) > Group C (Kesho alloy) > Group B (Noble golden dental alloy).

All samples in group D (Ni-Cr) showed bending at loads which were highest (779.67 kg) followed by group A, group C and lowest by group B. This states that group D has highest yield strength (80,000 psi)[13] followed by Group A (40,000 psi). This could be explained on the basis of higher nickel and molybdenum content (67 and

5% respectively) providing strength.[9,14] Carbon, although present in traces (0.2-0.4%) also helps in strengthening of alloy by forming carbides. Among the technique alloys tested, kesho alloy showed higher failure threshold than noble golden dental alloy. This could be explained on the basis of composition provided by the manufacturer*. Although, the exact percentage of constituents was not disclosed but it was reported that they mainly contain copper with zinc and silver as other constituents. Since, Majority of early fractures occured in groups B and C samples can be explained as copper has less yield strength than Ni-Cr and Gold thus, decreasing its failure threshold.

In the study, the mean failure load of all the alloys tested exhibited a range of 105 to 780 kg, which far exceeds the normal average masticatory loads of 20 kg.[15] This states that even the technique alloys tested have a failure threshold fivefold than the normal masticatory load which establishes their adequate strength but *in vitro*.

Thus, the utility of the technique alloys tested can be suggested for the fabrication of cast posts and core, provided found biocompatible with the living tissues.

Though, the study was carried out simulating intra-oral conditions, we should remember that it is an *in vitro* study and only compressive load was applied which may not exactly reflect *in vivo* conditions where loads of different magnitude is applied from different directions.

The future research should be directed to carry the study *in vivo* conditions keeping in mind the bio compatibility and other mechanical properties as major determinants, with the aim to provide a healthy and happy smile to every patient.

CONCLUSION

1. The mean failure loads recorded for all the samples tested were higher than the average masticatory load.
2. Ni-Cr group showed highest failure threshold followed by type III gold alloy, kesho alloy and least for noble golden dental alloy.
3. The technique alloys can be used as an alternative to gold and base metal alloys for fabrication of custom cast posts in terms of failure threshold.

REFERENCES

1. Rivera EM, Yamauchi M. Site comparisons of dentine collagen cross-links from extracted human teeth. Arch Oral Biol 1993;38(7):541-546.
2. Guntmann JL. The dentin root complex: anatomic and biological considerations in restoring endodontically treated teeth. J Prosthet Dent 1992;67(4):458-466.
3. Fauchard P. The surgeon dentist (Translated from the 2nd ed. 1746). Pound Ridge, NY, Inc; 1969;2:87.
4. Shillinburg HT, Fisher DW, Dewhirst RB. Restoration of endodontically treated posterior teeth. J Prosthet Dent 1970; 24(4):401-409.
5. Bergman B, Lundquist P, Sjögren U, Sundquist G. Restorative and endodontic results after treatment with cast posts and cores. J Prosthet Dent 1989;61(1):10-15.
6. Cheung W. A review of the management of endodontically treated teeth. J Am Dent Assoc 2005;136(1):611-619.
7. Cohen S, Burns R. Pathways of the pulp. 4th ed. St Louis: CV Mosby Co; 1987. p. 640-684.
8. Shillinburg HT, Hobo S, Whitsett LD, Jacobi R, Brackett SE. Fundamentals of fixed prosthodontics. 3rd ed. USA; Quintessence Publishing Co; 1997. p. 181-210.
9. Phillips RW. Science of dental materials. 9th ed. WB Saunders Company; 1992.
10. Fountain SB, Camp JH. Traumatic injuries. Cohen S, Burns R. Pathways of the pulp. 6th ed. Mosby; 1994. p. 436-485.
11. Moyers RE. Handbook of Orthodontics. 3rd ed. Chicago. Yearbook Medical Publishers Inc; 1977. p. 411.
12. Wheeler RC. Dental anatomy, physiology and occlusion. 5th ed. Philadelphia; WB Saunders Co; 1974. p. 436.
13. Marzouk MA, Simonton AL, Gross RD. Operative Dentistry: Modern Theory and Practice. Ishiyaku Euro America, Tokyo. St. Louis. 1st Indian ed; 1977. p. 311.
14. Dale JW, Moser J. A clinical evaluation of semi-precious alloys for dowels and core. J Prosthet Dent 1977;38(2):161-164.
15. Zarb GA, Bolender C. Bouchers prosthodontic treatment for edentulous patients. 10th ed. CV Mosby; 1990.