Comparative evaluation of wear resistance of cast gold with bulk-fill composites: an in vitro study

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Abstract

Aim: The aim of this study was to compare the wear resistance of cast gold with condensable bulk fill and a fiber reinforced bulk-fill composite.

Materials and Methods: The 5 mm × 4 mm stainless steel molds were prepared for wear resistance. Forty-five samples were divided into three groups (n = 15). The samples were restored as follows: Group I: cast gold alloy (D. SIGN 98; Ivoclar Vivadent), Group II: fiber reinforced composite (Ever X Posterio; r GC Corp.), and Group III: condensable bulk-fill composite (Tetric N Ceram; Ivoclar Vivadent). A pin on disc wear tester was used to measure the wear resistance. Data were analyzed using one-way analysis of variance.

Results: Higher statistically significant values were seen for the cast gold restorations than the other two bulk-fill composites.

Conclusion: It is desirable for any restorative material to yield wear behavior. D. SIGN 98 (Type IV cast gold alloy) was the most wear resistant material tested, whereas Tetric N Ceram (condensable bulk-fill composite) was the least wear resistant.

Keywords: Bulk-fill composite; cast gold; Tetric N Ceram; wear resistance

INTRODUCTION

We, in dentistry, still have choices to make. Esthetic dentistry has become a major focus in recent years, and it is difficult to know if this interest is generated by the patients or by the dentists. Resin-based composites have been introduced five decades ago and since then, they have gained popularity as a restorative material of choice, mainly due to its excellent esthetic properties.1-2 They also have replaced amalgam and gold as a posterior restorative material. Although a variety of composites including conventional, microfilled, hybrid, flowable, packable, nanofilled have been introduced, the main disadvantage of the resin-based composites is its polymerization shrinkage which exerts forces on the adhesive interfaces of the dentin.3-4 Furthermore, due to the insufficient depth of cure5 of resin-based composites, incremental placement technique with a maximum 2 mm thickness was used. However, the use of dental composites in an incremental placement technique and light curing each increment individually is time-consuming for the patient and the operator.6

Recently, a new class of resin-based composite, the so-called “bulk-fill” composites have been introduced into the dental market with the purpose of time and thus cost savings.7 The unique advantage of this material class is stated that it can be placed in a 4 mm thickness bulks to be used in one step instead of the current incremental placement technique, without adverse effect on polymerization shrinkage and cavity adaptation.

 Earlier, gold was considered to be the esthetic restorative for posterior teeth as it does not discolor the teeth and the


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color gold was considered less objectionable than other materials. As we have become more aware of esthetics in dentistry, we also have developed new techniques even with gold which do not destroy the beauty of a smile. There is a renewed emphasis on intracanal gold restorations, which can be placed by showing no metal or in some cases, very little metal, by the proper design of cavity preparations.

Despite the improvement in wear resistance of restorative materials, wear continues to be a problem. Gradual wear of the teeth is a natural process. The rate of wear depends on individual factors such as the abrasiveness of the diet, oral habits such as bruxism or grinding. Wear resistance is one of the most difficult properties to evaluate in material sciences. One of the most common reasons for the failure of posterior composites is occlusal and proximal wear. High wear resistance leads to an increased lifetime of the restoration, color stability, and function. Conversely, low wear resistance may lead to tooth migration, TMJ tenderness, and periodontal diseases.

MATERIALS AND METHODS

The materials used in the study are summarized in Table 1.

Specimen preparation
A stainless steel mold of 10 mm diameter and 4 mm thickness was fabricated. The cast gold fillets were melted over an oxygen blow torch and poured over the stainless steel mold. Fifteen such samples were prepared.

To prepare samples using bulk-fill composites, a mylar strip was placed over a glass slab, and the stainless steel mold was placed over it. The bulk-fill composite material was packed in bulk inside the mold until it was slightly overfilled. A second mylar strip was placed over the composite resin, and a glass slide was slightly compressed to extrude excess material. The flash is removed, and photoactivation was performed by positioning the light tip in contact with the specimen. Each specimen was irradiated according to the manufacturer’s instructions for 10 s with a blue phase C8 light-curing unit (Bluephase C8 (G2)–Curing Light (100–240V), Ivoclar Vivadent, Schann, Liechtenstein). Specimens were retrieved from the mold and stored in deionized water at 37°C for 24 h. They were then grouped as follows.

- Group I: Cast gold alloy (d. Sign 98)
- Group II: Fiber reinforced composite (Ever X Posterior)
- Group III: Nanohybrid resin composite (Tetric N-Ceram).

Wear testing
The wear testing was performed using Pin-On-Disc Wear Tester (ASTM G99, Magnum Engineers, Karnataka, India) as shown in Figure 1.

Wear tests were conducted on a pin-on-disc wear tester as per ASTM G-99 standard. Sliding was performed under room conditions (temperature 23°C, relative humidity 50% ± 5%) over a period of 2 min at a sliding velocity of 50 m/s. The surface of one of the faces of the 10 mm × 4 mm specimen came in contact with a hardened alloy steel disc with a hardness value of 62 hC and surface roughness (Rg) of 0.54 µm. The contact schematic diagram of the counter-surface and the sample is shown in Figure 1. Before testing, the test samples were polished against a 600 grade SiC paper to ensure proper contact with the counterface. The surfaces of both the samples and the disc were cleaned with a soft paper soaked in acetone.

![Figure 1: Schematic diagram of Pin-On-Disc Wear Tester](image-url)

Table 1: Materials, manufacturers, and chemical composition used in the test

| Product name       | Type                  | Composition                                                                 | Manufacture                  |
|--------------------|-----------------------|----------------------------------------------------------------------------|------------------------------|
| d. Sign 98         | Type IV casting alloy | Au - 85.9%                                                                 | Ivoclar Vivadent, Amherst, NY, USA |
|                    |                       | Pt - 12.1%                                                                 |                              |
|                    |                       | Zn - 1.5%                                                                  |                              |
|                    |                       | Ir - <1.0%                                                                 |                              |
|                    |                       | Mn - <1.0%                                                                 |                              |
| Ever X posterior   | Fibre reinforced resin composite | Bis-GMA, TEGDMA, PMMA, triethylene glycol, dimethacrylate, glass fillers and inorganic granular fillers | GC Co Tokyo Japan              |
| Tetric N-Ceram     | Nanohybrid resin composite | Bis-GMA, urethane dimethacrylate, TEGDMA, barium glass, ytterbium fluoride, silicon dioxide, mixed oxide, initiators, stabilizers, pigments | Ivoclar Vivadent, Schann, Liechtenstein |
| Bulk-fill          | Nanohybrid resin composite | tri fluoride, silicon dioxide, mixed oxide, initiators, stabilizers, pigments |                              |

Au: Gold, Pt: Platinum, Zn: Zinc, In: Indium, Ir: Iridium, Ta: Tantalum, Mn: Manganese, Bis-GMA: Bisphenol A glycidyl methacrylate, TEGDMA: Triethylene glycol dimethacrylate, PMMA: Polymethyl methacrylate
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and thoroughly dried before testing. The pin assembly was initially weighed to an accuracy of 0.0001 g. The difference between the initial and final weights was the measure of sliding wear loss. Fifteen samples were run for each group. The wear was measured by the loss in weight, which was then converted into wear volume using the measured density data.

The specific wear rate ($K_s$) is calculated using Equation (1):

$$K_s = \frac{\Delta V}{L \cdot d \cdot N \cdot m}$$

Where: $\Delta V$ is the volume loss, in m$^3$, $L$ is the load, in N, and $d$ is the abrading distance, in m.

**Statistical analysis**

The data obtained from the study was manually entered into a Statistical Package for the Social Sciences (SPSS) database (IBM, SPSS version 20, IL, USA) and analyzed with a significance level established at $P < 0.05$. Mean and standard deviation (SD) of weight loss for each test material were calculated and analyzed using one-way analysis of variance. Post hoc tests were performed for multiple comparisons and independent samples.

**RESULTS**

The mean weight loss of each test material and SD is given in Table 2.

The highest mean weight loss was observed for Tetric N-Ceram (1.39) followed by Ever X Posterior (1.29). Cast gold had the lowest wear resistance (0.405). The graphical representation clearly depicts the same in Figure 2.

**DISCUSSION**

Wear is normally a slow process.[8,9] The clinical manifestation of attrition shows the appearance of a flat circumscribed facet on the restorative material. As the wear progresses, there is a tendency toward reduction of the cusp height and the flattening of the occlusal inclined planes which may ultimately lead to loss of vertical dimension.[9] A well-distributed occlusion has an important effect on the wear process.[10] Gold alloy restorations have a long history of satisfactory clinical performance and are said to be kind[11] to opposing tooth substance and restorative materials, wearing at approximately the same rate as enamel.[12-14]

Resin-based composites show higher wear rates when placed as large posterior restorations. However, with higher filler content, they show the lesser wear of opposing tooth substance. Thus, wear of composites is known to depend on filler particle-related features, particularly on the concentration and size of the filler reinforcement[15] and resin formulation.[16] Finer particles for a fixed-volume-fraction of filler have been documented to result in decreased interparticle spacing and thereby reducing wear.[17,18] In terms of filler content, some in vitro wear studies have revealed that increased loading may enhance the wear resistance of dental composites.[19,20] As for the resin formulation, the study has shown that increasing resin viscosity generally lowers the wear resistance.[21]

Bulk-fill restorative resins are not a new idea. The concept has been in the mind of practitioners and manufacturers for many years, and numerous bulk-fill products have come and gone from the market. Recently, numerous bulk-fill resin-based composites introduced have been introduced.[22] The main advantages of bulk-fill composites are that they present fewer number of voids, since all of it is placed at one time, the technique would be faster than placing numerous increments if curing times were identical and most of all they may be easier than placing numerous increments. Moreover also, due to the higher filler content of bulk-fill composites, greater will be the depth of cure, reduced volume of resin matrix for polymerization and intrinsically increased hardness.[22]

The enhancement of material properties in fiber reinforced bulk-fill composites was explained due to the stress transfer from the matrix to the fibers and also due to the action of the fibers in stopping crack propagation through the
material.\textsuperscript{[24]} It was found that the mere insertion of fibers is not only responsible for the enhanced wear resistance but also the length of the fibers and diameter play a critical role in this mechanism. The E glass fibers incorporated in the Ever X Posterior bulk-fill composite have a length (1–2 $\mu$m) that exceeds a certain minimum length (0.6–0.8 $\mu$m). This is known as the critical fiber length.\textsuperscript{[25]}

The largest particles of the inorganic fillers of Tetric N-Ceram Bulk-fill measure 3 $\mu$m. The composite fillers have a maximum size of 50 $\mu$m. In the polymerized state, they behave like the smaller inorganic primary particles.\textsuperscript{[26]} The larger filler particles do not protrude from the surface. The fine primary particles of the fillers are responsible for the composite’s wear resistance and its excellent polishing properties, which are manifested in smooth surface texture and high luster.

The present results were obtained in optimized laboratory settings. However, clinical conditions are not similar, and the aspects such as insertion and handling could have a potential effect on the mechanical properties of the materials and their performance \textit{in vivo}. Further investigations should be conducted to test other material properties. To acknowledge the results obtained with the present study, this should be followed by long-term clinical studies to assure the materials performance under normal clinical conditions.

**CONCLUSION**

In the current study, cast gold has superior wear resistance than compared to the other two tested materials going by the proverbs “the old that is strong does not wither, and The deep roots are not reached by the frost.”

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**Conflicts of interest**

There are no conflicts of interest.

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