

## Original Article

# Lingual retainer materials: Comparative evaluation of wear resistance of flowable nanocomposites and universal composite: An *in vitro* study

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## ABSTRACT

**Background:** A bonded fixed retainer is used to stabilize the alignment of the teeth. Different composites have been introduced for this purpose. This study aimed to investigate the wear resistance of flowable nanocomposite in comparison with microhybrid composite in an *in vitro* situation.

**Materials and Methods:** In this *in vitro* study, 46 disk-shaped specimens were divided into two groups: Filtek Ultimate flowable composite and Z250 microhybrid composite. The samples were prepared in 8 mm diameter and 3 mm thickness in an aluminum mold and light cured. They were polished with 600 grit sandpaper to achieve a smooth surface. Two-body wear test was accomplished by the pin-on-disk device (under 15 N, 20 rpm for 1 h). Analyzing the weight and thickness of specimens before and after the assay demonstrates the wear resistance. Data were analyzed using the *t*-test.  $P \leq 0.05$  was considered statistically significant.

**Results:** The Filtek Ultimate flowable composite shows no significant difference compared to Z250 microhybrid composite in thickness ( $P = 0.701$ ) and weight ( $P = 0.939$ ) of specimens.

**Conclusion:** Due to wear resistance of both materials, flowable composite can be recommended as an alternative material for bonded fixed retainers.

**Key Words:** Composite resins, dental restoration wear, orthodontic retainers

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## INTRODUCTION

An attractive smile is an expectation of most patients who are treated orthodontically.<sup>[1]</sup> As a result, different methods such as Removable and fixed appliances have been developed to maintain the stability of teeth position posttreatment, which is achieved in the course of treatment.<sup>[2]</sup> The decision of the proper retention regimen for each patient is made by the consultation with clinicians and patients.

The first-generation method for the posttreatment retention was banded fixed appliances followed with removable retainers and bonded lingual retainers later.<sup>[3]</sup> Demands for permanent maintenance of esthetic results are increased due to posttreatment discrepancies.<sup>[4]</sup> Anterior crowding in both untreated and orthodontically treated patients would be occurred because of decreasing in arch length and width due to

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age.<sup>[5]</sup> Retainers are meant to be worn for extensive periods of time.<sup>[6]</sup> This prolonged presence of retainer exposes it to many inadvertent changes; therefore, multiple follow-up visits are necessary for checking intactness and durability of retainers.<sup>[6]</sup>

Increasing the cost of treatment and compromising the efficiency of retention are the results of the retainer's failure.<sup>[7]</sup> Orthodontic wire and composite are two components of bonded fixed retainers.<sup>[8]</sup> Failure at the adhesive–wire interface is the most common failure type that occurred due to insufficient adhesives and modified occlusal contacts which result in composite abrasion.<sup>[9]</sup> 62% of the subjects in the mandibular and maxillary retainers revealed abrasive wear of the composite – brushing and mastication cause mechanical forces that have been correlated with the abrasion of mandibular retainers.<sup>[10]</sup>

Several composites, such as restorative and orthodontic bonding material, have been reported for the use in the technique.<sup>[6]</sup> The noticeable factor that should be considered at the time of choosing a composite for bonding is the wear resistance.<sup>[11]</sup> Even though the wear resistance of conventional composites is not a major clinical issue, the wear of new products such as flowable nanocomposites has not been studied.<sup>[11]</sup> From the other point of view, flowable composite obtained popularity as a result of its ease of handling,<sup>[12]</sup> such as being premixed, direct, and exact composite placement due to its needle tips, no trimming and polishing required, and reduced chair time.<sup>[13]</sup> Nevertheless, as mentioned before, wear resistance of the flowable composite is a concern. Accordingly, we intended to investigate the wear resistance of a flowable nanocomposite (Filtek Ultimate) in comparison with a microhybrid composite (Z250) by pin-on-disk machine. It was hypothesized that wear resistance of flowable nanocomposite is not different from the conventional equivalent.

## MATERIALS AND METHODS

In this experimental study, 23 disk-shaped specimens (diameter 8 mm, thickness 3 mm) of each material were prepared in an aluminum mold. This study was approved by the Committee of Medical

Ethics of Isfahan University of Medical Sciences (398188). The following formula was used to calculate the sample size, based on a similar study; an  $\alpha$  error = 0.05 and test power of 80% were considered so that 23 specimens per group (total seven groups) would be required to detect possible differences.

$$n = \frac{(Z_{1-\alpha/2} + Z_{1-\beta})^2 (\delta_1^2 + \delta_2^2)}{d^2}$$

The composite resins were filled into the mold in increments (each layer thickness approximately 1 mm) and light-cured under the manufacturer instructions (480 nm, 20 s, Woodpecker, Guilin, China). To achieve a smooth surface of the composite resins, a thin glass slab (thickness 1 mm) was placed under the mold. Specimens were cured by laboratory light-curing devices (480 nm, 60 s, Kerr, Michigan, USA) to acquire the same conversion effect. Finally, the cured specimens were pushed out of the mold, and to achieve a uniform roughness among samples, they were polished using a 600-grit silicon carbide sandpaper (Bosch, Stuttgart, Germany) for 1 min. Specimens were fixed in a plastic holder and stored in the artificial saliva (NikCeram Razi, Iran) at 37°C in a digital incubator (Behdad, Tehran, Iran) for 7 days before testing (to remove soluble ingredients). Preparation and numbering of samples were carried out by one researcher, and another one performed testing specimens separately for a blinded study. Two-body wear test was selected to wear the assessment by the pin-on-disk device (Sayesh Co., Isfahan, Iran) in Torabinejad Research Center.

Two groups of the composites were used in this study: Flowable nanocomposite (Filtek Ultimate, 3M, ESPE, Minnesota, USA) and universal microhybrid (Z250, 3M, ESPE, Minnesota, USA). Details of composites are shown in Table 1.

After 1 week, the weight of specimens was measured using a digital scale accurate to 0.001 g (Gf 600, Tokyo, Japan). Further, the thickness of samples was measured by digital calipers (100624, Shanghai, China, scale with 0.01 accuracy) in triplicates. A mean of thickness was calculated. The thickness and weights of the holder [Figure 1] were added to

**Table 1: Material's details**

Brand name	Type	Filler size	Filler type	Matrix resin	Manufacturer
Filtek ultimate	Nanofilled	<100 nm	Zirconia/silica cluster	UDMA, TEGDMA, BISEMA, PEGDMA	3M, ESPE
Z250	Microhybrid	0.01-3.5 $\mu$ m	Zirconia/silica	UDMA, TEGDMA, BISEMA, PEGDMA	3M, ESPE

the thickness and weight of specimens. All holders had the same thickness and weight.

In the pin-on-disk device, an antagonist material (silicon carbide sandpaper with 1000 grit) was installed on the mandrel of the device [Figure 2], and the prepared disk-shaped specimens with holder were fixed on the other compartment of the device. The disks were rotated around the axis by an electrical motor and in the vertical pattern under 15 N force and 20 rpm for 1 h under running distilled water as the lubricant. After the wear test was completed, all specimens were stored in the artificial saliva at 37°C for 1 week (to be under pre-treatment condition) in a digital incubator. Weight and thickness of samples were measured again. Data were analyzed using *t*-test.

## RESULTS

Differences in the thickness and weights of the specimens before and after wear tests were measured to clarify the wear resistance of two composites. The *t*-test analyzed the data. For all statistical evaluation, statistical software (SPSS 17 for windows, IBM, USA) was used. Differences in the thickness (mm) and weight (g) of flowable nanocomposite before and after the test were  $0.32 \pm 0.15$  mm and  $0.009 \pm 0.001$  g, respectively. These data for Z250 composite were  $0.30 \pm 0.12$  mm and  $0.009 \pm 0.005$  g, respectively. The mean thickness and weight of both composites are shown in Table 2. As seen in Figures 3 and 4, there was no statistically significant difference between the two composites after the wear test. In addition, Graphs 1 and 2 show a linear correlation between thickness and weight loss during the test.

## DISCUSSION

A key part of orthodontic treatment is retention.<sup>[14]</sup>

Bonded fixed retainer has been used for many years to improve the stability and to prevent the inadvertent tooth movement or relapse.<sup>[15]</sup> Two classifications of failures exist: One is based on the extension of failure (partial or complete), while another is based on the type of failure (failure at tooth–composite/composite–wire interface, breakage within the wire).<sup>[14]</sup>

Abrasion of the mandibular retainer is related to mechanical forces.<sup>[10]</sup> Garcia *et al.* pointed out that the

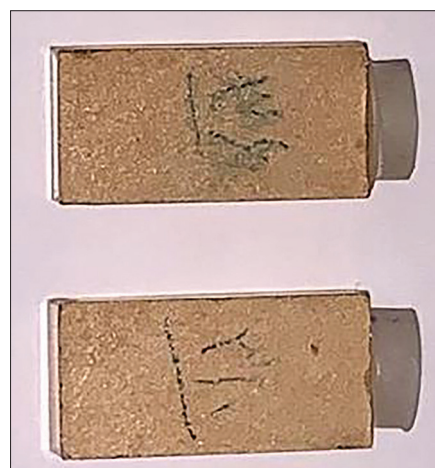


Figure 1: Samples with plastic holder before smoothing process

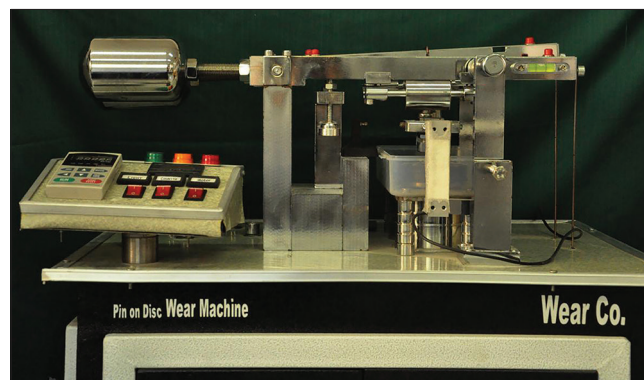
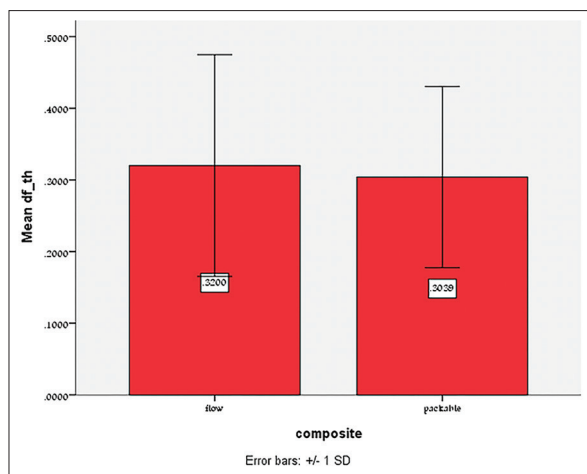


Figure 2: Pin on Disc Wear Machine (Sayesh CO., Isfahan, Iran)

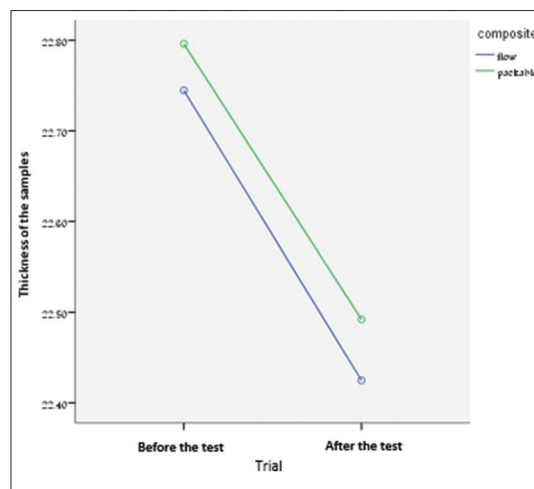
Table 2: The mean thickness (mm) and weight (g) of both composite

Composite	Report					df_w
	Thickness B	Thickness A	Weight B	Weight A	df_th	
Filtek ultimate						
Mean	22.7448	22.4248	1.38761	1.37852	0.320000	0.009087
SD	0.31752	0.28838	0.024081	0.024038	0.1547138	0.0018319
Minimum	22.14	21.94	1.339	1.328	0.1400	0.0060
Maximum	23.47	22.98	1.446	1.435	0.6800	0.0120
Z250						
Mean	22.7961	22.4922	1.45313	1.44413	0.303913	0.009000
SD	0.16395	0.14061	0.030477	0.031972	0.1265177	0.0050901
Minimum	22.42	22.23	1.410	1.396	0.0500	0.0020
Maximum	23.29	22.90	1.549	1.537	0.5700	0.0210

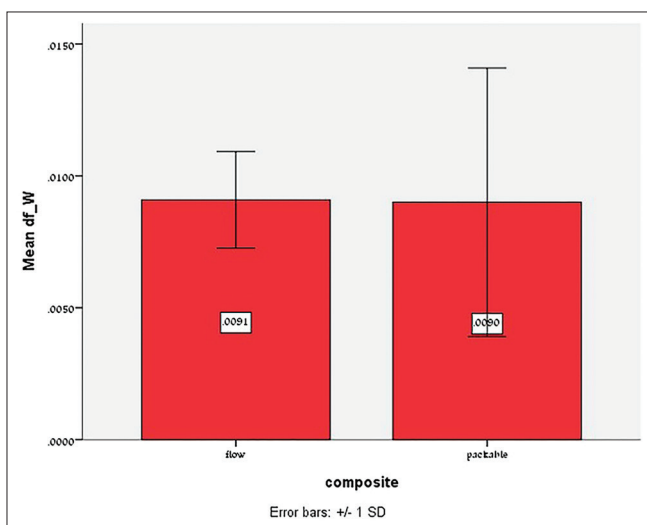
B: Before; A: After; df: Differences; th: Thickness; w: Weight; SD: Standard deviation



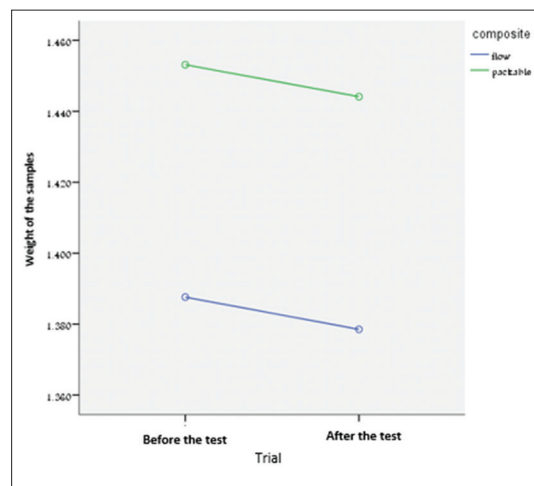
**Figure 3:** The mean differences in thickness (mm) before and after the wear test in both composite. \*df: Difference; th: Thickness; Flow: Filtek ultimate; Packable: Z250



**Graph 1:** Linear correlation between thickness (mm) loss during the trial. \*Flow: Filtek ultimate; Packable: Z250



**Figure 4:** The mean differences in weight (g) loss before and after the wear test in both composites. \*df: Difference; W: Weight; Flow: Filtek ultimate; Packable: Z250



**Graph 2:** Linear correlation between weight (g) loss during the trial. \*Flow: Filtek ultimate; Packable: Z250

wear of the resin can be the reason for the abrasion mechanism of the composite because it leads the creation of spaces that are varying among the size of the filler. In their study, they tested the wear of the composite by tooth brushing simulation.<sup>[16]</sup>

There are two types of wear test: two-body and three-body wear test.<sup>[17]</sup> Two-body wear analysis aims to simulate wear caused by contact of materials such as teeth or restoration during bruxism and grinding. Three-body wear test involves the masticatory phase when food exists.<sup>[18,19]</sup> We evaluate our specimens by a two-body wear test.

Wear results from abrasion, attrition, adhesive effect between two surfaces, fatigue, and corrosion effect.

Abrasion and attrition are known as clinical wear mechanism for dental composites.<sup>[20]</sup> Filler levels, volume, hardness, and degree of polymerization and adhesive strength between filler and resin matrix influence wear.<sup>[20-22]</sup>

Currently, flowable composite elevated since better handling properties.<sup>[23]</sup> Increasing the resin content beyond that of the highly filled composite results in the fluidity, which can question wear properties of the flowable composite.<sup>[23]</sup>

Since the introduction of nanotechnology to composite resins, the characteristics have improved. Nanoparticles that incorporate with composite resin would allow for better mechanical properties and flowability in the flowable composite.<sup>[24]</sup>

In this study, we examined the newest flowable nanocomposite “Filtek ultimate ESPE,” as results

showed that thickness and weight of the flowable composite in our study were not significantly different from microhybrid composite after wear test under 15 N forces and 1000 grit sandpaper for 1 h. This result does not reject the null hypothesis. This also supports previous studies. Palaniappan *et al.* stated that the mean vertical and volume wear of the nanofilled group was not significantly different from microhybrid.<sup>[25]</sup> As well, Veli *et al.* indicated that the shear bond strength of the flowable composite was not substantially different from a conventional one when using as the lingual retainer.<sup>[12]</sup>

Furthermore, Asefi *et al.* stated that flowable composite such as Estelite flow quick and Estelite flow quick High flow composite had a comparable wear resistance compared to p60 (microhybrid) composite.<sup>[21]</sup>

Moreover, Paolone *et al.*, who investigated tensile test and retention forces of a micro- and nano-filled composite and microhybrid composite, concluded that nano- and micro-composite tolerate stronger forces and exhibit higher bonding value in comparison with microhybrid composite.<sup>[15]</sup> This result supports the better mechanical properties of newer composite products. Similarly, Talik *et al.* mentioned that the overall prevalence of the failure of fixed mandibular lingual retainer bonded with two different flowable composites was not significantly different, and the failure rate was lower when using either two of the flowable composites than using conventional composite.<sup>[14]</sup>

On the other hand, Han *et al.*, who measured abrasive wear of several composite resins, found out that some flowable composite was inferior to universal composite; otherwise, some flowable composite indicated comparable abrasive wear resistance.<sup>[11]</sup>

From these outcomes, it can be deduced that incorporation of smaller-sized filler may be advantageous in contrast with a large-sized filler for localized wear resistance of flowable composite as Shinkai *et al.* reported.<sup>[22]</sup> In addition, they stated that a mean filler sized of 400 nm showed significantly lower wear resistance in a two-body wear test in comparison with those containing mean filler size of 70–200 nm.<sup>[22]</sup> In our study, flowable nanocomposite contains a mean filler size <100 nm.

In detail, incorporation of fillers of fine particle size improved wear resistance of composite resin due to the reduction of filler shedding during the wear process.<sup>[20,26]</sup> Indeed, in Filtek Ultimate

composite (DEB shades), as per the manufacturers, nanoclusters comprised about 90% of the filler that provides strength, fracture, and wear resistance. This volume of nanocluster can enhance bond strength, too.<sup>[27]</sup> To our knowledge, no previous studies evaluate the wear resistance of Filtek ultimate ESPE.

Another explanation for better mechanical properties and wear resistance of Filtek Ultimate is that its matrix resin is different from previous products. The majority of TEGDMA in this composite is replaced with UDMA, according to the manufacturer. Previous studies have shown that TEGDMA assisted as the diluent and reduced the viscosity, whereas UDMA and BisEMA provided strength and revealed better mechanical testing.<sup>[28]</sup> An increase in resin viscosity showed a progressive increase in wear.<sup>[29]</sup> In this composite, the high molecular weight material (UDMA and BisEMA) also impacted the measurable viscosity and provided better bond strength and wear resistance.

There were some limitations in our study. One of them was a two-body wear test. Lacking of a three-body wear device in our university was the reason. Furthermore, the size of our samples was small, and SEM analysis was not carried out. Our study performed in an *in vitro* situation; Regardless of this known limitation, further studies are better to be accomplished in an actual clinical case.

## CONCLUSION

It can be concluded that flowable nanocomposite, which contains nanoparticles, can be used for lingual retainers, due to its mechanical properties and wear resistance, which is comparable to conventional composite. Indeed, filler loading and incorporation of UDMA in the resin matrix elevated the features that make the Filtek Ultimate flowable composite as an ideal material for bonding lingual retainer.

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## Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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