Comparative Study Of Wear Resistance Of The Composite With Microhybrid Structure And Nanocomposite

1. V Nagabhushana Rao , 2. P Vijaya Kumar , 3.S.Hemaltha , 4.S Rama Lakshmi Malladi

1. Professor, Department of Mechanical Engineering, Raghu Institute of Technology (A), Visakhapatnam. AP.

2. Professor, Department of Mechanical Engineering, Raghu Institute of Technology (A), Visakhapatnam. AP.

3. Associate Professor, Department of Mechanical Engineering, Raghu Institute of Technology (A), Visakhapatnam. AP.

4. Assistant Professor, Department of Mechanical Engineering, Raghu Institute of Technology (A), Visakhapatnam. AP.

Abstract:

To compare microhardness and wear resistance of ceramic-polymer composites with micro and nanohybrid structures. The investigations employed commercial composites with nano-sized (Filtek Ultimate) and micro-sized (Filtek Z250) filler particles. A ball-on-disc micro-tribometer was used for testing.Microhardness was measured using the Vickers technique and the Futertech FM 700 equipment. Filtek Ultimate has been almost doubling the wear resistance of Filtek Z250 composite. The inclusion of filler nanoparticles enhanced the material's wear resistance. Also, there is no association between material microhardness and wear resistance.

Key words: Wear Resistance, Dental Composites, Microhardness

1. INTRODUCTION:

conservatism Popular are ceramic-polymer composites. It applies to front teeth, molars, and premolars. Physical-mechanical properties of ceramicpolymer composites fit oral cavity circumstances (Canche-Escamilla et al., 2014). Long-lasting aesthetics resemble real tooth tissues. Clinically, they should guarantee filling longevity.

Composites have a matrix (organic phase-resin) and filler (inorganic phase). Size, shape, quantity, and distribution of filler particles in resin matrix affect dental composites' mechanical and tribological characteristics (Wang et al., 2015). Silica, glass, and quartz are common fillers.

New materials are continually being researched to boost filling abrasion resistance (Hambire and Tripathi, 2013). Modern dental composites have microfillers above 0.04 m and nanofillers above 0.005 m. (Schmalz, 2009). Fillers are applied as agglomerates or distributed. Nano-sized filler particles improve ceramic-polymer composites' physical and mechanical qualities (Wang et al., 2015). Type of composite determines filler amount in matrix. Hybrid composites feature the largest ratio of inorganic to organic phase, with filler content ranging from 60 to 70% of composite volume or 70 to 85% of composite mass (percent weight).

In vitro investigations employing material specimens are the first step in classifying novel dental composites. In vitro tests are preliminary. It shortens in vivo research and clinical trials (Ramalho and Antunes, 2005). Surface hardness and abrasion resistance are crucial preclinical investigations. It increases filling wear resistance and reduces opposing tooth wear (contact teeth). During chewing, surface degradation may retain particles. They collect trash and plaque. As a consequence of the above events, filling surface stains may form, degrading aesthetics. Also, filling biocompatibility lowers (Palaniappan et al., 2013).

Wear on composite fillings is caused by opposing tooth contact, food intake, teeth brushing, and disorders such bruxism. Wear is a combination of abrasive wear, adhesive wear, fatigue of the surface layer, and corrosive effects (Mair et al., 1996). Abrasion and attrition cause tooth wear (Palaniappan et al., 2013). Three bodies cause abrasive wear: opposing teeth's friction surfaces and foreign particles. In composite fillings, abrasive wear exposes filler particles by abrading the polymer matrix (Lambrecht et al., 2006). Attrition is wear induced by direct contact between opposing dental surfaces, resulting from two bodies interacting. Microroughness interaction occurs between rough surfaces. Both hard and brittle body surfaces flex and shatter after surpassing a critical stress value due to microroughness contact. When one surface is harder than another, microcutting may induce quick wear (Mair, 2000).

Wear resistance must be correlated with friction coefficient. According to Kleczkowska and Bieliski (2007), too high friction coefficients might cause premature filling wear, while too low can reduce food crushing efficiency. The friction coefficient of composites in liquid or suspension is 0.2 to 0.45, according to the authors.

The level of composite wear depends on the size and content of the filler particles in the composite structure and the filler adhesion to the resin matrix (Turssi et al., 2007). If the filler particle sizes and space between them are smaller than contact distortions and deformations, the material behaves almost as a homogeneous one, and its wear is similar to resinous matrix wear. When filler particles and deformation size are same or filler particles are bigger, the material acts as heterogeneous and wear is lower than resinous base wear (Kleczkowska and Bieliski, 2007). The 'protection theory' can explain ceramic-polymer wear resistance. Polymer is less wear-resistant than filler particles, hence composite wear relies on resin spacing (Ferracane and Palin, 2013). High filler amounts in the matrix and tiny particle size increase composite surface tribological characteristics under excellent dispersion.

2. MATERIAL AND STUDY METHOD:

Filtek Z250 and Filtek Ultimate, commercial ceramic-polymer composites, were examined. Composites have same-type, different-size filler particles (Fig. 1, Fig. 2). Tab.1 provides material data.

Tab. 1. List of the studied materials (Thomaidis et al., 2013)

Material	Manufacture	Type	Type and size of filler particles	Filler particles content (vol.%)
Filtek Z250	3M ESPE	Micro-hybrid	$SiO2/ZrO2$ 0.01-3.5 μm	60
Filtek Ultimate	3M ESPE	Nanocomposite	SiO2 20 nm, ZrO2 4-11 nm, 0.6-20 μm clusters	63.3

ISO 4049-compliant microhardness specimens were disc-shaped. LEDs cured samples for 40 seconds.

The Vickers technique was used on a Futertech FM 700 device with a 50 g load and a 20-second penetration period. All measuring coordinates were set to cover the whole specimen surface. Twenty samples were light exposed (LC) and nonexposed (NLC).

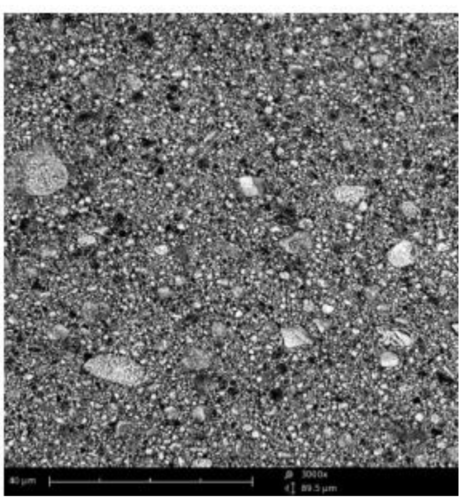

Fig. 1. SEM microstructure of Filtek Z250 composite; zoom 3000x

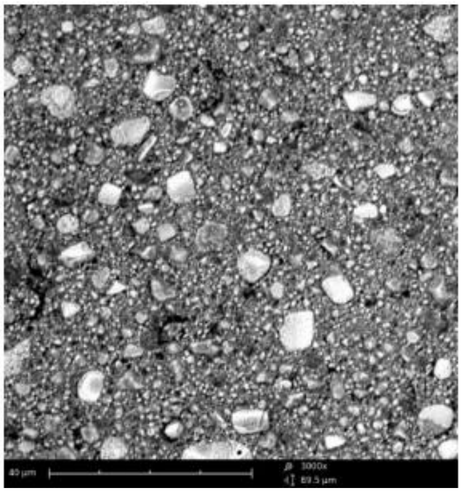

Fig. 2. SEM microstructure of Filtek Ultimate composite; zoom 3000x

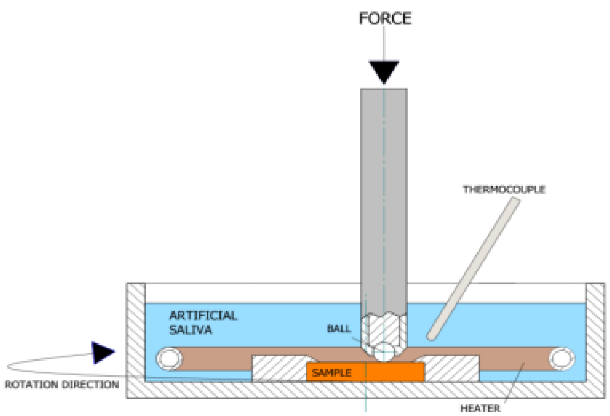

Fig. 3. Schematic diagram of wear test apparatus

Microtribometer (CSM Instruments SA Switzerland) ball-on-disc technique was used to measure wear resistance. Aluminum trioxide 6-mm spherical counter specimens were used (Al2O3). Throughout the test, specimens were submerged in artificial saliva to replicate oral circumstances. Test load was 5 N. 100 m was slid at 60 rpm. Surface profiler VeecoDektak 150 was used to study wear geometry. 8 samples were tested for light-exposed wear resistance (LC). Fig. 3 depicts the test machine's schematic.

3. STUDY RESULTS AND DISCUSSIONS:

Tab. 2 shows composite microhardness experiments. LC and NLC surfaces were considered. Study findings descriptive statistics: Average, minimum, maximum, dispersion, standard deviation

Tab. 2. Microhardness measurement results

Material	Surface	Average	Min	Max	Dispersion	St. Dev.
		[HV]				
Filtek Z250	LC	72.78	59.53	83.05	23.52	3.790
Filtek Ultimate	LC	72.99	63.98	80.19	16.21	3.927
Filtek Z250	NLC	75.24	65.66	82.37	16.71	3.490
Filtek Ultimate	NLC	71.56	64.89	78.10	13.21	2.743

LC – exposed side
NLC – non-exposed side

Z250 and Ultimate have comparable microhardness. LC and NLC have similar average values.The composites manufacturer may explain.Fig. 4 shows friction coefficient vs. distance. Materials investigated had comparable friction coefficient vs. distance curves.

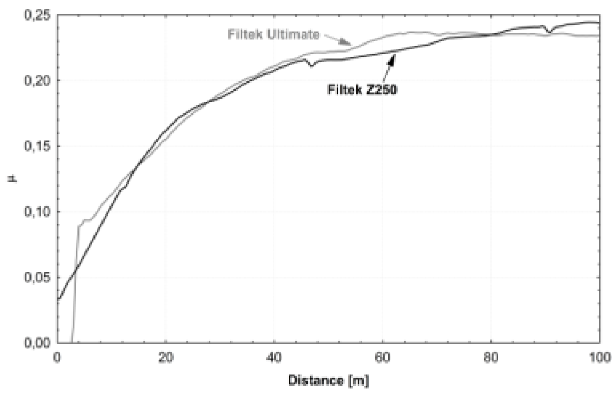

Fig. 4. The curve illustrating changes of friction coefficient vs. distance at the load of 5N

3. Tabularize wear research findings. Microhardness and average wear coefficient K are described. Fig. 5 shows the wear profiles of Filtek Z250 and Filtek Ultimate.

Filtek Ultimate's wear resistance was greater than Filtek Z250's. Maximum Filtek Ultimate wear was 363x105 m3, lower than Z250 composite. Filler particle size affects wear. Some writers suggest composites with smaller filler particles are more wear-resistant (Souza et al., 2016). Filler content affects wear resistance, research show (Wang et al., 2003). Despite comparable wear mechanisms, comparing method outcomes is problematic (Heintze at el., 2005).

Tab. 3. Results of dental composites wear

Material	Average	Min	Max	Dispersion	St. Dev.	Average wear coeff. K
	$10^5 \mu m^3$					$[m^3F^{-1}m^{-1}]$
Filtek Z250	412	245	596	351	90	$8.23x10^{-14}$
Filtek Ultimate	227	124	363	239	76	$4.54x10^{-14}$

Based on the wear studies, the wear coefficient K, including loading and sliding distance was determined. The coefficient for Filtek Z250 was 8.23x10-14 [m3F -1m-1] and for Ultimate it was 4.54x10-14 [m3F -1m-1].

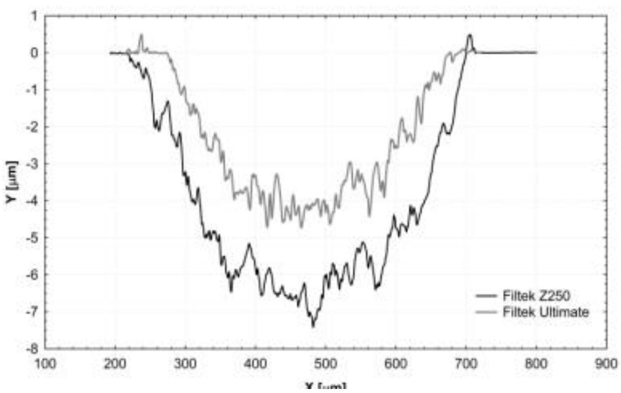

Fig. 5. Typical wear profiles

Figs. 6 and 7 illustrate Z250 and Ultimate composite wear tracks. Figure shows six parallel furrows. In Fig. 7, furrow margins show microcrack propagation directions. Microcracks branch and reconnect, separating particles into scales. This separates particle from composite surface.

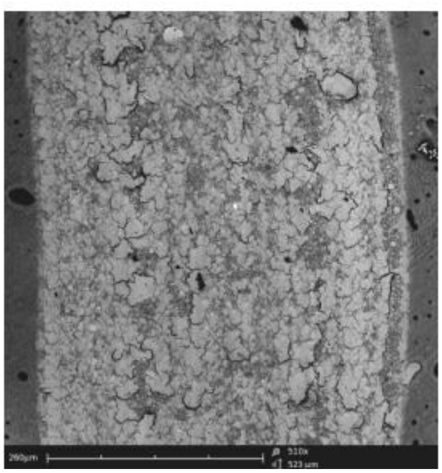

Fig. 6. Wear track of Filtek Z250 composite; zoom 510x

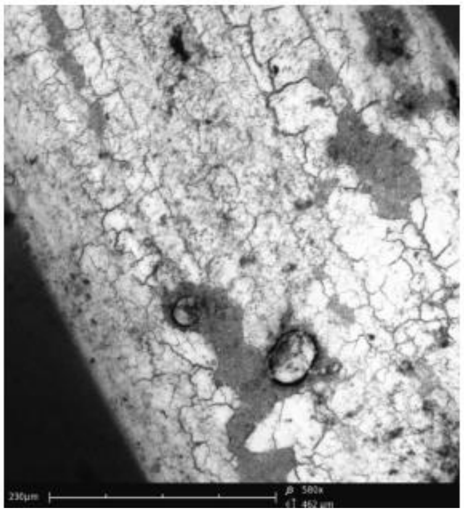

Fig. 7. Wear track of Filtek Ultimate composite; zoom 580x

4. CONCLUSION:

In the experiments, both composites had identical microhardness. Composite microhardness and polymerization shrinkage value are correlated. Microhardness research may also be utilised to examine local photopolymerization gradient, composite property inhomogeneity in polymerization lamp light effect region.

Filtek Z250 composite shows substantially greater adhesive wear than Filtek Ultimate. Different composite structures may affect wear. Ultimate composite's surface layer is strengthened by nanoparticles. SEM pictures indicated only small material gaps, whereas Filtek Z250 wear traces were linear.

The wear of composites relies on the filler amount and particle size (Finaly et al., 2013; Turssi et al., 2007; Wang et al., 2013). Despite identical filler content, Z250 and Ultimate composites have superior wear resistance owing to smaller filler particles (Tab. 1). Ultimate composite's filler dispersion was superior; material was more uniform, with less spaces between particles, resulting in decreased wear owing to improved load transmission between matrix and filler.

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