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COMPARATIVE STUDY OF THE BENDING STRENGTH OF DIFFERENT FLUID COMPOSITE FELLING MATERIALS

Abstract. *This study aimed to investigate the flexural strength of light-curable composites used for dental restorations, using the three-point bending technique. Flexural strength is defined as the ability of a material to withstand deformation under pressure. For this study we used CLEARFIL, Kuraray composites. Based on the study, it can be concluded that fluid composites show superior flexural strength to composite composites.*

Keywords: *fluid composites, flexural strengths, tooth restoration.*

Composite materials used in modern dentistry list a number of properties, such as: mechanical properties, low viscosity, high radiopacity, low shrinkage of polymerization and of course the depth effect of restorations, etc. Given the properties

listed above, it is obvious that this type of material has gained great popularity in the last decade, worldwide and locally. The aesthetic treatment, in addition to restoring and increasing the quality of the smile, operates with the harmonies of colors and the naturalness of the forms of the final restoration. The composites used in Dentistry offer us the possibility to offer our patients sustainable, qualitative and of course aesthetic results in a short period of time.

An important step in the history of modern restorative dentistry was the development of light-curable composite resins for direct procedures. Improvements in the mechanical properties of composite materials and light curing devices have allowed their use for the lateral group of teeth [1, 13, 20, 29]. In 1996, fluid composites were developed and presented to the world as revolutionary biomaterials for restorations [9].

The evolution of adhesive dentistry, with sealants and adhesives with filling, led to the discovery of fluid composite resins. Since 1996, they have acquired their own identity and become known as fluids. The first generation liquid formulas aimed at simplifying the application techniques and at the same time expanding the range of clinical application of resin composites [16]. They were configured using filler with particle size identical to that of hybrid composites, reducing the amount of filler and increasing the volume of diluent monomer [25, 3].

The filling content, the particle size and the particle distribution strongly influence the physical and mechanical properties of composite materials [2, 29, 34]. Manufacturers have increased the filler content and reduced the average filler particle size to produce resin-based composites for Class II rear restorations, which need adequate strength and wear resistance to withstand the masticatory forces they are subjected to. suppose [20, 29, 34].

In particular, improved handling characteristics have led to an increased popularity of conventional fluid composites and fluid fillers. In addition to the ability to stick to hard tooth tissues, mediated by adhesive systems, they have the advantage of good aesthetics and are less expensive compared to cast gold or ceramic inlays [19, 33].

However, insufficient material properties have limited the success of composite restorations in high-strength areas [19, 33]. Fracture inside and at the edge of restorations, shrinkage after polymerization have been mentioned as major problems in terms of failure of subsequent restorations [31]. The properties of materials such as fracture strength, occlusal pressure deformation and marginal degradation of materials have usually been assessed by determining the basic parameters of the material for flexural strength and fracture strength [8]. The values of fracture strength depend on the mechanical properties and the chemical composition of the components contained in the restoration material. A material that has a high fracture resistance has the ability to better withstand the initiation and spread of cracks. Consequently, the property of fracture strength and flexural strength become important criteria in the longevity of dental materials [14, 17]. **Purpose of the paper:** Comparative study of the flexural strength of fluid composite, chitosan and heated chitosan composites.

Research materials:

The following materials were used from the group of composites: *Clearfil AP-X ES-2* - chitos composite material; *Clearfil AP-X Esthetics Flow* - fluid composite material; *Clearfil S3 Bond Universal* - adhesive. The "Palodent Plus" set was used from the matrix group (figure 1).

Fig.1. Composites (a) and adhesive (b) used for restorations

• *Clearfil AP-X ES-2:* It is a nano-hybrid composite material with a thick consistency, produced by Kuraray Noritake Dental, Japan. Organic matrix composition - Bis-GMA. The total filling volume is about 78%, including inorganic filling of 40% volume. The dimensions of the inorganic filler particles vary from 0.37μk to 1.5μk.

• *Clearfil AP-X Esthetics Flow:* It is a composite material of fluid consistency, produced by Kuraray Noritake Dental, Japan. Organic matrix composition - TEGDMA. The total volume of inorganic filler is from 48% to 62% volume. Inorganic filler particle sizes range from 0.18μk to 3.5μk.

•*Clearfil S3 Bond Universal:* It is a one-component, light-curing adhesive system manufactured by Kuraray Noritake Dental, Japan. It is indicated for direct and indirect restorations in combination with the 3 engraving techniques (complete engraving, self-engraving and selective engraving).

Study - Flexural strength of composite materials. This study aimed to investigate the flexural strength of light-curable composites used for dental restorations, using the three-point flexion technique (figure 2).

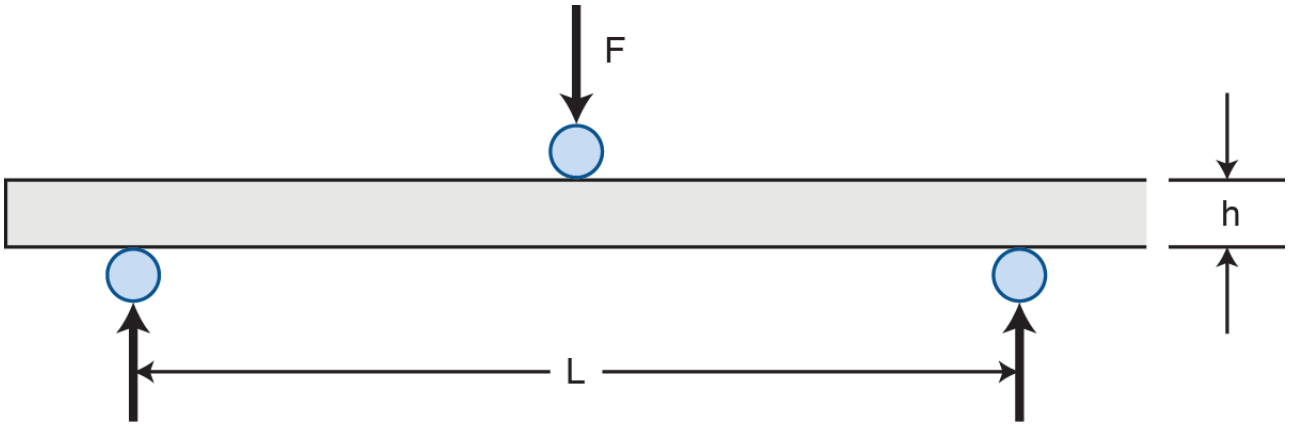

Fig.2. Schematic representation of the 3-point bending test

Flexural strength is defined as the ability of a material to withstand deformation under pressure. For this study we used CLEARFIL, Kuraray composites (table 1).

Table 1

Materials and samples used to perform the test

Group	Composite	Producer	Color / Lot	Nr. of samples	Polymerization
1	CLEARFIL AP-X ES-2	CLEARFIL AP-X ES-2 (Kuraray Noritake Dental Inc., Japonia)	D2/ 260007	7 pieces 4 mm wide length 20 mm thickness 2 mm	based on the instructions for use
2	CLEARFIL AP-X Esthetics Flow	CLEARFIL AP-X Esthetics Flow (Kuraray Noritake Dental Inc., Japonia)	A3D/ BM0017	7 pieces 4 mm wide length 20 mm thickness 2 mm	based on the instructions for use
3	CLEARFIL AP-X ES-2 55˚ C	CLEARFIL AP-X ES-2 (Kuraray Noritake Dental Inc., Japonia)	D2/ 260007	7 pieces 4 mm wide length 20 mm thickness 2mm	based on the instructions for use

For this purpose, 7 samples (figure 3) in the form of a semi-cylindrical bar (≈4x2x20mm) were prepared for each type of material, divided into 3 groups: chitosan composite, fluid composite and chitosan composite heated to t˚55C (table 2). A hard silicone matrix was made to prepare all the samples. The chitosan composite was applied and condensed to ensure a consistent thickness for all samples.

Table 2

Composite materials used for testing

Composite	Producer	Organic matrix composition	Filling composition
CLEARFIL AP-X ES-2	CLEARFIL AP-X ES-2 (Kuraray Noritake Dental Inc., Japonia)	Bis-GMA	78% of the volume particle 0.37µm - 1.5µm
CLEARFIL AP-X Esthetics Flow	CLEARFIL AP-X Esthetics Flow (Kuraray Noritake Dental Inc., Japonia)	TEGDMA	48% - 62% of the particle volume 0.18µm - 3.5µm

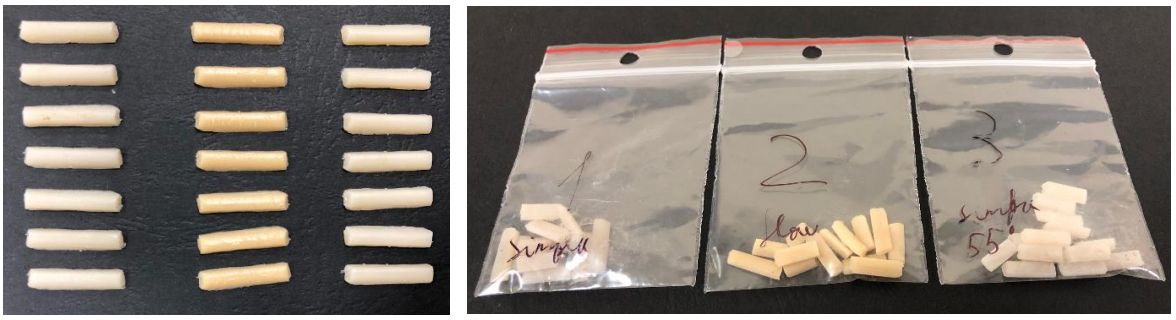

Fig 3. Samples in the shape of a semi-cylindrical bar

The samples were polymerized according to the instructions for use recommended by the manufacturer. With the help of the polypants, the surplus material was removed and then all the dimensions of the samples were checked with the help of the caliper. Subsequently, the samples were subjected to the bending test by the 3-point bending method. For this purpose, a modified device was prepared, which was made based on the available sources to which I had access. Thus, the force from the midpoint of the sample from the bottom to the top was applied. An electronic scale was used to assess the applied force, and the data obtained were noted with the help of video recordings (figure 4).

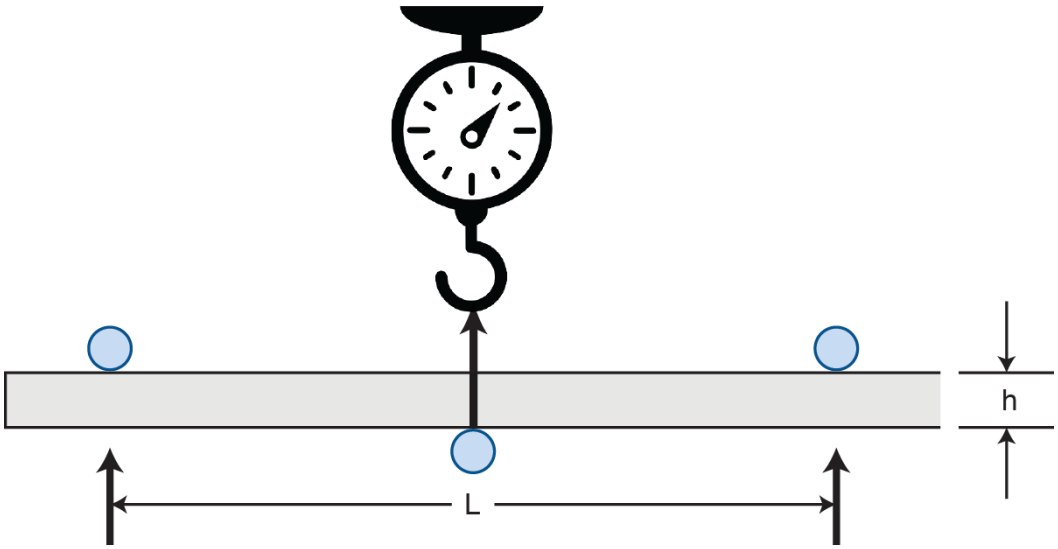

Fig 4. Schematic representation of the modified 3-point bending test

The maximum fracture load (F, in N) (maximum applied force that led to the fracture of the sample) of each sample was recorded and then the flexural strength (σ_f) in MPa was calculated as follows:

$$\sigma_f = 3FL/2bh^2$$

where:

L: distance between supports (13 mm);

b: sample width (≈4 mm);

h: sample thickness / height (≈2 mm).

The results were statistically analyzed for q = 5% (P = 95%). The error of the experiment was assessed by calculating the standard deviation of the data sample, after censoring the data with exaggerated deviations from the other values in that sample.

The following table (table 3) presents the data obtained from the experiment, namely: the characteristics of the samples (b, h), the force (F) applied to cause the breaking of the samples, the values of flexural strength (σ_f) expressed in megapascals (MPa) for each sample , mean bending strength values for all three groups and sample mean error.

Table 3

Bending strength values for individual samples according to groups, their mean values and error

Group 1	Width (mm)	Thickness (mm)	Weight (kg)	Force (N)	σf (MPa)	Error
1	4.20	2.40	3.800	37.28	30.0	
2	4.05	2.45	3.820	37.47	30.1	
3	4.10	2.50	3.115	30.56	23.3	
4	4.10	2.50	3.900	38.26	29.1	
5	4.00	2.30	3.795	37.23	34.3	
6	4.00	2.30	4.765	46.74	43.1	
7	4.15	2.50	4.910	48.17	36.2	
Medie	**31.9**					**3.2**
Group 2	**Width (mm)**	**Thickness (mm)**	**Weight, kg**	**Force, N**	**σf (MPa)**	**Error**
1	4.00	2.40	4.590	45.03	38.1	
2	4.10	2.30	6.675	65.48	58.9	
3	4.00	2.15	6.595	64.70	68.2	
4	4.05	2.35	5.535	54.30	47.3	
5	4.05	2.05	5.935	58.22	66.7	
6	4.00	2.30	6.215	60.97	56.2	
7	4.00	2.20	8.400	82.40	83.0	
Medie	**59.5**					**8.5**

Table continuation 3

Group 3	Width (mm)	Thickness (mm)	Weight, kg	Force, N	σf (MPa)	Error
1	4.05	2.55	6.955	68.23	50.5	
2	4.00	2.35	5.425	53.22	47.0	
3	4.05	2.60	5.095	49.98	35.6	
4	4.10	2.65	6.505	63.81	43.2	
5	4.05	2.50	4.525	44.39	34.2	
6	4.00	2.55	5.800	56.90	42.7	
7	4.15	2.60	6.440	63.18	43.9	**4.2**
Average	**42.5**					

Two values from each group were excluded from the mean calculation (highest and lowest value) due to the highest deviation from the mean, after which a sample of 5 samples based on which the average calculation was performed remained, and error assessment for the experimental sample (standard deviation). The highest mean value was found to be in group 2 (59.5 ± 8.6 MPa), followed by group 3 (42.5 ± 4.2 MPa) and group 1 respectively (31.9 ± 3.2 MPa). Fluid composite materials showed statistically higher average σf values compared to the researched composite composites.

It is noteworthy that the values of the confidence intervals for all samples do not overlap, increasing in the range Group 1 <Group 3 <Group 2. In other words, the materials studied obviously differ in flexural strength, but the data obtained are very credible.

$$\textbf{Group 1: } \sigma_f \in (28{,}7;\ 35{,}1)$$

$$\textbf{Group 3: } \sigma_f \in (38{,}3;\ 46{,}7)$$

$$\textbf{Group 2: } \sigma_f \in (51{,}0;\ 68{,}0)$$

Based on the large differences between the values of flexural strengths, and the lack of overlapping confidence intervals for each sample (in fact, for different materials), as well as the sufficient number of samples in each sample (5 samples left after censorship), it can be concluded, that fluid composite materials demonstrate superior flexural strength to composite composites.

Conclusions:

1. The materials studied obviously differ in flexural strength and the data obtained are very credible.

2. Fluid composite materials demonstrate superior flexural strength to composite composites.

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