

A comparative evaluation of flexural strength between direct and indirect veneering composite resins: An in-vitro study

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ARTICLE INFO



Keywords: Dental composite, polymerization, resin, flexural strength, restorative material, filler, indirect composite

ABSTRACT

The clinical performance of dental composites has been significantly improved over the past decade through modifications in a formulation that includes: using more stable polymerization promoters for greater color stability; incorporating high concentrations of finely ground fillers to produce adequate strength and excellent wear resistance while retaining translucency; adding radiopacifying agents for improved diagnostics, and utilizing dentin adhesives. Light-cured composites resins are an important group of restorative materials in dentistry and can be used to restore the shape and function of anterior and posterior teeth. The mechanical properties of a restorative material are a crucial factor in their clinical performance including compressive, tensile, and/or flexural strength. These properties are strongly related to the composition (filler content, organic matrix) of the material and may be altered depending on the characteristics of the light source used for curing. The aim of this in vitro study was to evaluate the flexural strength of the direct and indirect composite.

Introduction

A smile has been said to be among man's most important interactive communication skills ^[1]. The practice of dentistry has changed significantly in the past 2 decades. The older perceptions of dentists and previous treatment regimens have been replaced with extensive media coverage of cosmetic dentistry and the various options to improve a patient's smile. The public is more knowledgeable about cosmetic dentistry and elective esthetic treatment options ^[2, 3].

Dental composite formulations have been continuously evolving ever since Bis-GMA was introduced to dentistry by Bowen in 1962 ^[4]. Direct composite resins offer excellent optical and mechanical properties, their use in larger posterior restorations is still a challenge since polymerization shrinkage remains a concern in cavities with high C-factor. Though there have been numerous advances in adhesive systems, it is observed that the adhesive interface is unable to resist the polymerization stresses in enamel-free cavity margins ^[5, 6].

One of the drawbacks of direct composite resin restorations is polymerization shrinkage. IRCs were introduced to reduce polymerization shrinkage and improve the properties of the material ^[4]. First-generation composite resins were microfilmed composite resins. Their failure rate was high because they featured a low flexural strength (60-80MPa); a low modulus of elasticity (2000-3500 MPa); and a low resistance to abrasive wear, owing to a low percentage of inorganic filler particles and a high percentage of exposed resin ^[7, 8]. The clinical failures endured with first-generation composites and the limitations faced with ceramic restorations led to the development of improved second-generation composites ^[9]. Second-generation composite resins (ceramic polymers) provide good esthetics, with a wide range of hue, chroma, opacity, biocompatibility, and tissue preservation ^[7]. These materials are microhybrid composites with a volume percentage of inorganic fillers of approximately 66%, resulting in improved mechanical properties with flexural strength between 120 and 160 MPa and elastic modulus of 8.5-12 GPa ^[10]. These systems are

indicated for inlays and Onlays laminated veneers and jacket crowns, implant-support restorations, adjustment of proximal contacts, and reduction of occlusal stresses in bruxism cases [3].

Veneering with ceramic is an established and successful technology for the anterior and posterior regions [11]. The flexural strength of the veneering ceramic ranges from 55 to 150 MPa [12]. Veneering ceramics provide excellent biocompatibility, color stability, and abrasion resistance [13, 14]. However, ceramic-veneered restorations have (numerous) undesirable characteristics, such as time-consuming fabrication. They are also technically demanding and may damage the opposing natural (dentition) [15]. Alternatively to ceramic, indirectly fabricated composite resins have been developed [11]. IRCs can supplement and complement (rather than replace) ceramic restorations [4]. The composition of these indirect, veneering composite resin systems is similar to that of the direct composite resins, but they differ in additional polymerization [10, 11]. The mechanical and physical properties of veneering composite resins are based on their chemical composition: resin matrix, filler particle type, filler size, filler percentage, and filler-matrix bonding (silane coupling agent). Temperature, environmental conditions, and the light intensity of the polymerization unit are all important factors [11, 16]. In addition, longer light exposure and posturing by heating have been found to improve the properties of prosthetic composite resin materials in laboratory studies. Most veneering composite resins are applied with a post-curing process through heat and photopolymerization, which results in better flexural strength than veneering ceramic, minimal polymerization shrinkage, and a wear rate comparable to tooth enamel [11, 17].

The success of any dental restorative material depends upon its physical, chemical, and mechanical properties [18]. In the oral cavity, restorative materials are subjected to cyclic mechanical and thermal loading (fatigue). Evidence exists indicating fatigue is responsible for the wear, chipping, and generalized failure of dental restorative materials [19, 20]. The properties of composite resin are known to depend upon the nature of the matrix, type of filler, filler volume, and filler/matrix interfacial bond. Under oral conditions, in addition, intraoral temperature changes may be induced by routine eating, drinking, and breathing. They may cause the failure of the filler/ matrix interfacial bond because of the mismatch of the thermal expansion between matrix and filler

in composite resin. This attack upon the composite resin may affect its physical properties and influence its durability [18].

3M Filtek™ Z250 Universal Restorative is an esthetic, light-cured, radiopaque composite specifically designed for use in both anterior and posterior direct or indirect restorations. In Filtek Z250 restorative, the majority of TEGDMA has been replaced with a blend of UDMA (urethane dimethacrylate) and Bis EMA (Bisphenol A polyethylene glycol diether dimethacrylate). Both of these resins are of higher molecular weight and therefore have fewer double bonds per unit of weight [21].

3M™ Filtek™ Z250 Universal Restorative exhibited approximately an 18% reduction of total volumetric shrinkage when compared to 3M™ Z100™. The particle size distribution is 0.01µm to 3.5µm with an average particle size of 0.6µm [21].

Tetric N-Ceram is a universal composite for anterior and posterior restorations. Nanocomposites thus have been introduced to serve these functional needs through the application of nanotechnology. Tetric N-Ceram has improved mechanical properties i.e. better compressive strength, diametrical tensile strength, fracture resistance, wear resistance, low polymerization shrinkage, high translucency, high polish retention, and better esthetics. Tetric N-Ceram also exhibits optimal aesthetic properties and therefore are good candidates for anterior restorations [22].

A brand of indirect resin composites, SR Nexco (Ivoclar Vivadent) was introduced in 2012. This laboratory composite is indicated in the fabrication of the framework-free dental restorations (inlays and onlays). The micro filler used for SR Nexco paste is a highly dispersed silicon dioxide with particles in the range of 10 to 50 nm. The main filling component is a prepolymer/ copolymer which consists of pre-polymerized ground-up UDMA matrix and inorganic micro filler particles [23]. The balanced ratio between the matrix and filler components results in outstanding physical properties achieved with polymerization units. This technology allows for the superior strength of resin composite [24].

Intraorally, restorative materials are subject to mechanical, chemical, and thermal influences through eating, drinking, and breathing. Therefore, the purpose of this study is to

compare and evaluate the flexural strength and discoloration of direct and indirect veneering composite resins ^[25].

MATERIALS AND METHODOLOGY

MATERIAL	COMMERCIAL NAME	MANUFACTURING COMPANY
CONVENTIONAL COMPOSITE	FILTEK Z250	3M
CONVENTIONAL COMPOSITE	TETRIC N CERAM	IVOCLAR VIVADENT
INDIRECT COMPOSITE	SR NEXCO PASTE	IVOCLAR VIVADENT

All veneering composite resins were prepared and polymerized with their corresponding polymerizing light according to the manufacturers' instructions.

A rectangular stainless steel mold was taken of dimensions 25x2x2mm for the preparation of the restorative materials used in the study.

The stainless steel mold was taken and 10 rectangular shaped samples of each restorative material, with a total of 30 samples, were prepared.

GROUPING OF SAMPLES:

The prepared 30 samples were then distributed into three groups of 10 samples each.

- **Group A (n = 10): Filtek Z250**
- **Group B (n = 10): Tetric N Ceram**
- **Group C (n = 10): SR Nexco**

Finishing was performed with a fine-grit diamond finishing

bur. Flexural strength tests were performed in a universal testing machine.

STATISTICAL ANALYSIS

The statistical analysis was done using Statistical Package for the Social Sciences (SPSS for Windows, Version 16.0. Chicago, SPSS Inc.). Descriptive statistics were calculated for all variables as mean and standard deviation. Normality testing was done using the Shapiro-Wilk test which showed that the data were normally distributed ($P > 0.05$).

The comparison of study parameters among the study groups was done by a post-hoc test for multiple comparisons. The level of significance for the present study was fixed at a p-value of less than 0.05.

OBSERVATION AND RESULTS

Sample No.	Group A Filtek Z250	Group B Tetric N Ceram	Group C SR Nexco
1	140.8	126.3	80.34
2	135	118.69	87.68
3	138.9	115.6	78.36
4	126.56	121.12	76.94
5	132	121.14	91.86
6	150	121.91	72.34
7	119	119	71.37
8	125.8	122.69	69.6
9	131	130.13	68
10	136.86	117.9	74.3

DISCUSSION

Composite resin restorations are more affordable than many porcelain counterparts, can be placed chairside without laboratory fees, and are easily repaired when required. Composite resin has become the material of choice for both anterior and posterior restorations [2, 3].

The most basic mechanical property of restorative material is its strength [26]. Flexural strength is considered the best measure of the strength of dental materials and is defined as the maximum stress a material can resist before failure; considerable stresses may occur during the complex process of mastication. Flexural strength is neglected because of its minimal preparation [27, 28]. **Heintze et al** reported that flexural strength was a good indicator of a material's durability under stress, and it correlated well with clinical longevity [29].

Therefore, the present study evaluated the flexural strength and discoloration of three composite materials Filtek Z250 (3M), Tetric N Ceram (Ivoclar), and SR Nexco (Ivoclar).

Among the experimental groups, Group C (SR Nexco) showed the least flexural strength of 77.0MPa which was statistically significantly lower when compared with both group A (Filtek Z250) and Group B (Tetric N Ceram).

This can be explained as an indirect composite containing 62.9% (w/w) pre/copolymer filler also silicon dioxide with particles size ranging from 10-15nm is dispersed throughout. This larger size of filler, less filler loading, shape, and silanization to the matrix attributes to less flexural strength as explained by **Reich SM et al** when compared with Filtek Z250 and Tetric N Ceram [30].

The lower performance of indirect composites that is group C revealed that enhanced secondary polymerization methods did not improve the mechanical properties of the indirect composites compared to the directly placed composite. The heat treatment itself does not imply better mechanical properties because properties may also be dependent on resin composition. These results were supported by **Cesar et al. (2001)** [31].

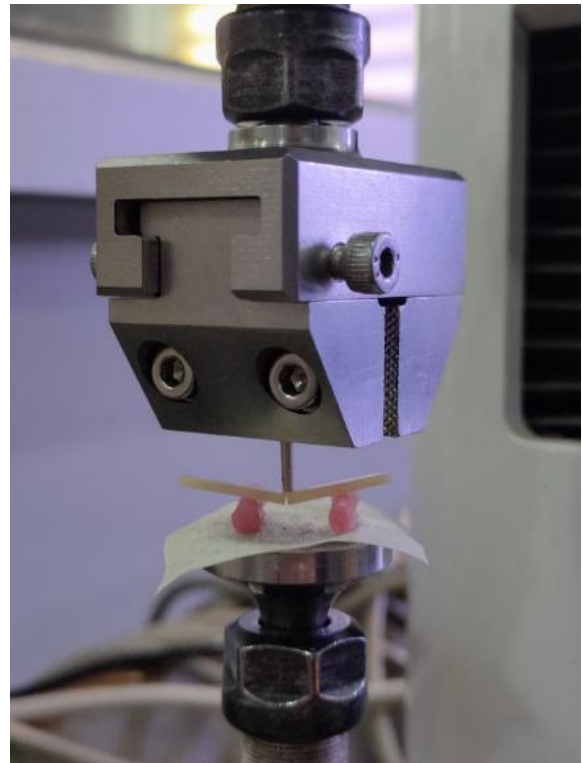


Fig: Universal Testing Machine

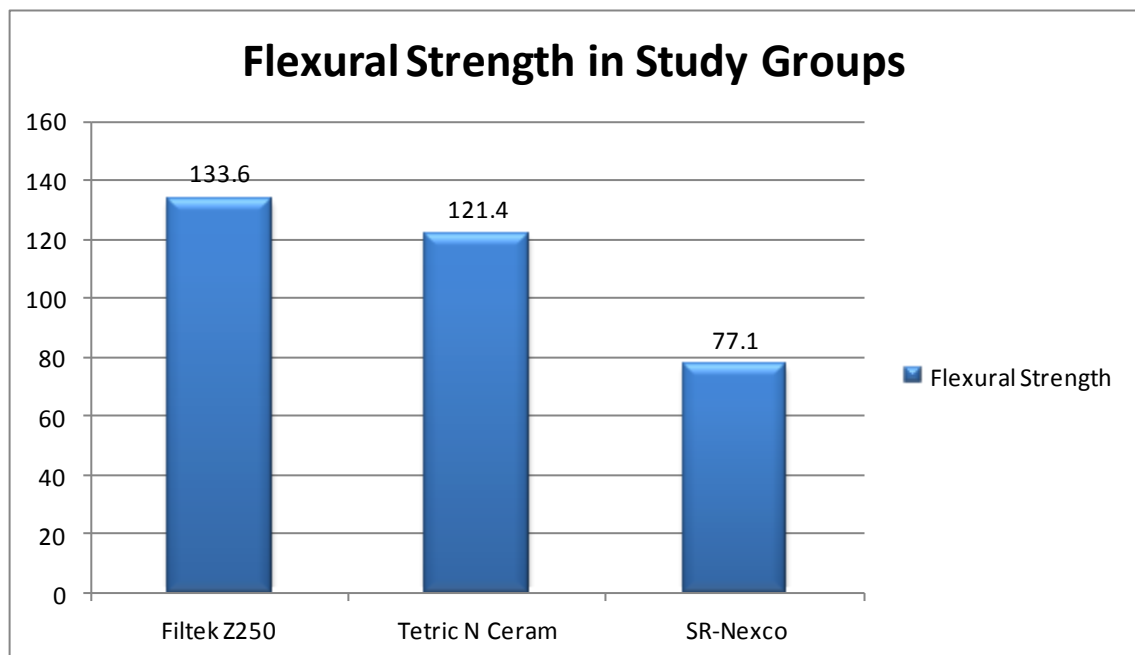
The results are from previous studies done by **Borba et al 2009**. It was speculated that mechanical properties may also be affected by the polymerizing system [10].

Therefore, it was expected that the mechanical properties of the new composites evaluated in this study were higher than those of the direct composite resins. However, the results of this study did not support this. This finding is in agreement with the results obtained by **Da Fonte Porto Carreiro A et al (2004)** ^[32].

Among the two groups that are Group B Tetric N Ceram with a mean flexural strength of 121.44 MPa was not statistically better than Group A Filtek Z250 which has the highest mean flexural strength of 133.59MPa.

Tetric N Ceram has a filler content of 70.5% by weight which was the same as that of Filtek Z250. However, they did not exhibit better or equivalent mechanical properties compared to Filtek Z250 or

SR Nexco. Therefore along with filler content, other factors such as filler size, composition, morphology, amount of initiators, and quality of silanization can also contribute to the development of physical and mechanical properties. Filtek Z250 consists of small and medium round shaped filler particles whereas nanohybrid composites like Tetric N Ceram consist of irregularly shaped filler particles ^[33]. Mechanical stress tends to distribute more uniformly with rounded particles than the irregularly shaped particles, that present sharp angles already known as stress



Graph 1: Flexural strength of tested restorative materials

Group	Group	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Filtek Z250	Tetric N	12.14400*	3.22021	.002	4.1598	20.1282
	Ceram					
	SR-Nexco	56.51300*	3.22021	.000	48.5288	64.4972
Tetric N	Filtek Z250	-12.14400*	3.22021	.002	-20.1282	-4.1598
	Ceram					
	SR-Nexco	44.36900*	3.22021	.000	36.3848	52.3532
SR-Nexco	Filtek Z250	-56.51300*	3.22021	.000	-64.4972	-48.5288
	Tetric N	-44.36900*	3.22021	.000	-52.3532	-36.3848
	Ceram					

*. The mean difference is significant at the 0.05 level.

Table 1: Showing Post Hoc multiple comparison of all groups P value significant, $P \leq 0.05$

concentration areas from where cracks may start. The filler size of Tetric N Ceram is large when compared to FiltekZ 250 [34]. The large surface area to volume ratio of the fillers present in Tetric N Ceram tends to increase water uptake and lead to degradation of filler matrix interphase thereby affecting the mechanical properties when compared to groups A, B, and C [35].

The composition of monomer affects the mechanical properties of present composites.

Filtek Z250 contains UDMA which may explain the reason for the higher flexural strength whereas Tetric N Ceram contains TEGDMA which may contribute to the lower flexural strength [33, 36].

Also, the presence of BA glass and ytterbium trifluoride Tetric n cream for fluoride release might be related to low Flexural strength. Also, the presence of TEGDMA monomer leads to lower Flexural strength as explained by **Ramdas R et al** [33].

Apart from factors associated with material composition and curing, the conditions of the oral environment are an important factor in considering the mechanical strength of composite materials. Water or other chemicals available in the oral cavity could with time, decrease the mechanical properties of composites. Once the network is saturated with water and becomes soft, the composite structure stabilizes and there is no further reduction in properties within the time frame studied.

Finally, knowing the restorative material's composition is important, as is respecting its polymerization cycle, promoting adequate surface texture to select the appropriate material for each clinical application, and using it competently to obtain its best properties, thus guaranteeing longevity and success [34].

CONCLUSIONS

Within a limitation of the study, it is concluded that:

- Filtek Z250 has the highest flexural strength followed by Tetric N Ceram. A however statistically significant difference was not seen between them.
- SR Nexco reported the least flexural strength.
- The nanohybrid resins (Tetric N Ceram) presented inferior properties compared to hybrid composite (Filtek Z250).
- Based on the finding from this study, for high stress-bearing applications, the materials of choice would be Filtek Z250 and Tetric N Ceram.

This study was carried out using simulated in vitro conditions hence results could vary in clinical conditions. Further in vivo analysis may be necessary for a better understanding of the strength of resins composites.

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