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Original Article

Enhancement of Flexural Strength of Two Nano-composites by Electron Beam Irradiation.

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Abstract

Aim : The study aimed to assess and investigate the effect of electron beam irradiation on the flexural strength of two newer nanocomposites (Filtek Z350XT and Filtek Bulkfill)

Materials and Methods: Forty samples each of both the nanocomposites were prepared on rectangular bar shaped moulds (25*2*2mm) according to ISO 4049. The dosage of electron beam selected for the study were 2KGy, 4KGy and 10KGy. The forty specimens were divided into four groups based on the radiation doses; group I: non radiated, group II: 2KGy , group II : 4 KGy, group II : 10KGy with ten samples in each group. The samples were subjected to a 3point bend test on a universal uniaxial servo mechanical testing machine.

Results: The data was statistically analyzed using One way Anova analysis. Analysis demonstrated that Filtek Z350XT had better flexural strength than Filtek Bulkfill ($P<0.001$). The flexural strength of the composites increased with the dose of electron beam irradiation.

Conclusion: Within the limitations of the study, it can be concluded that the electron beam irradiation of the nanocomposites can be used as a tool to enhance their mechanical properties.

Introduction

Replacement of the biological, functional and esthetic properties of sound tooth structure embodies the supreme goal of any dental restorative material[1]. Dental amalgam and gold alloy shave demonstrated the highest clinical success rates for more than 100 years, due to the similarities between their mechanical properties with those of the natural teeth[2]. Nevertheless, aesthetics portrays to be the chief disadvantage of these materials. The enigma of aesthetics in restorative materials has been resolved since the advent of resin composites. However, due to its inferior durability and strength, the use of composites waslimited[3]. Over the years, major developments have been undertaken to improvise the clinical performance of composites.

The necessity of functional demand of posterior restorations and the superior aesthetics required for anterior restorations has been met with the introduction of nanocomposites[4]. Nanocomposites encompass improved mechanical properties, which include superior compressive strength, diametrical tensile strength, fracture resistance, wear resistance, low polymerization shrinkage, high translucency, high polish retention and better aesthetics[3,4].

Electron beam is a stream of electrons generated by heat, bombardment of charged atoms or particles, or strong electric fields. Cross linking by electron beam irradiation is an effective substitute to cross linking by chemical agents [5]. The cross linking of the polymers severely impedes the molecular movement, causing the polymer to be stable against heat. The primary effects of electron beam irradiation are chain scission, oxidation and increased unsaturation, based on the dose rate and the oxygen content in the exposed environment[6].

The present study aimed to assess and investigate the effect of electron beam irradiation on the flexural strength of two nano-composites; Filtek Z350XT and Filtek Bulk fill in order to achieve enhanced flexural strength.

Materials and Methods

The flexural strength of Filtek Z350XT and Filtek Bulk fill was evaluated before and after electron beam irradiation.
The composition of the materials is given in the Table 1.

Operative procedure

Preparation and grouping of the specimens for flexural strength

A total of 80 samples; 40 samples each of two different composite materials having 10 specimens in each group were fabricated using customized bipartite brass mold measuring 25mm × 2mm× 2mm, according to ISO standard 4049.

Preparation of the specimens

The composite resins used for this study were two nano-composites, FiltekZ350XT and FiltekBulkfill, Posterior composite.

The composite resins were placed in mould. The composites were covered with a mylar strip. A glass slide (1mm thick) is then placed over composites and pressure is applied to accommodate the material into the mold and to extrude excess material. After removing the glass slide, the composites were then cured from the top and bottom surfaces through the mylar strip as per the manufactures instructions using the LED light curing unit. The specimens were taken out of the brass mould and light cured in the middle of the specimen at opposing sides. The study was performed in controlled temperature by keeping it in a distilled water bath for 24h at 37^{0}C.

Groups

In total, 80 specimens were fabricated and divided into 4 groups based on the irradiation dose.
Group 1 = non radiated
Group II=2kGy Group III= 4kGy Group IV= 10 kGy
The fabricated samples were subjected to their respective doses of radiation.

Standardization of dose

The materials were radiated using an 8 MeVMicrotron at Microtron Centre, Mangalore University, Mangalore, India. The doses indicated for the study were 2kGy, 4 kGy and 10 kGy.

Testing procedure

All specimens were subjected to the 3 Point bend test on a universal uniaxial servo mechanical testing machine (Model 33 R 4467; Instron Corp; 3M ESPE, Bangalore) individually and subjected to flexural strength analysis at crosshead speed of

0.75mm/min. [model no. 4206].

Table 1 : Composition of the Nanocomposites analyzed in the study.

Material	Composition
FiltekZ350XT (3MESPE, St.Paul, Minessota, USA) Bis- EMA	The resin matrix : Bis-GMA, UDMA, TEGDMA and The filler : Combination of aggregated zirconia/silica cluster with pri- mary particle size (5-20 nm), and nonagglomerated silica filler (20 nm).
FILTEK BULK FILL, Posterior Restorative (3MESPE, St.Paul, Minessota, USA) dodecane-DMA.	The resinmatrix: AUDMA, UDMA, and1, 12- The filler : Non-agglomerated /non-aggregated 20nm silicafiller, a Non-agglomerated/non-aggregated 4 to 11 nm zirconia filler, an aggregated zirconia/silica cluster filler (20nm silica and 4 to 11 nm zirconia particles), and a ytterbium trifluoride filler consisting of agglomerate 100 nm particles. (Khalil Yousef, 2015)

Results

The data obtained from the present study was subjected to statistical analysis using one-way ANOVA and inter group comparison is done using student t test.

The flexural strength of experimental groups was compared with one way ANOVA test, p value < 0.001 was obtained which indicates highly statistically significant

ANOVA.

Group		N	Mean	SD	Minimum	Maximum	ANOVA p value
1	Control	10	172.05	2.93	167.87	176.23	<0.001*
	2 kGy	10	285.45	3.48	280.34	291.36	
	4 kGy	10	341.92	5.79	334.52	353.21	
	10 kGy	10	388.60	11.13	375.63	407.15	
2	Control	10	155.26	2.54	151.32	158.24	<0.001*
	2 kGy	10	206.74	4.75	198.27	214.53	
	4 kGy	10	256.87	5.99	248.24	264.32	
	10 kGy	10	311.85	4.96	303.67	318.12	

difference between tested materials [Table2]. The Comparison off lexural strength between FiltekZ350 XT and FiltekBulkfill at different doses of radiation is depicted in Graph 1.

Discussion

The increasing demand for aesthetic dentistry during the last few decades has led to the advent of composite resin materials for direct restorations. The latest innovations and developments in the field have led to composite resins with improved physical and mechanical properties, esthetics and durability.[7, 8]The introduction of nano-filler technology, which involves combination of nano-metricparticles and nano clusters in a conventional resinmatrix, is the latest advance mentin the field[3]. These composites have demonstrated superior mechanical properties and are indicated for posterior restorations due to their high strength as well as anterior restorations due to their high esthetic properties. The mechanical properties of a material depict its response to loading. In most of the clinical situations, composite resin restorations undergo a considerable amount of flexuralstress[9]. Hence, ideal restorative materials are required to avoid deformation by masticatory stresses, which damage the marginal seal of the restoration[10]. Filtek Z 350XT is a nanocomposite with a combination of nanomer sized particles to the nano cluster formulations that helps decrease the interstitial spacing of the filler particles. This assures enhanced filler loading, superior physical properties when compared to the composites comprising of only nanoclusters.

Filtek Bulk Fill Posterior Restorative material is a visible, light-activated restorative composite. The fillers are a combination of a non-agglomerated/non-aggregated 20 nm silicafiller, a non-agglomerated/ non-aggregated 4 to 11 nmzirconia filler, an aggregated zirconia/ silica cluster filler and aytterbiumtri fluoride filler consisting of agglomerate

100 nm particles. This bulk fill material provides excellent strength and low wear for durability.

The electron beam irradiation has been proven to be an efficient method to structurally modify the materials,[11, 12]. Earlier studies have advocated the enhancement of mechanical properties on the compressive and flexural strengths of resin modified glass ionomer cement, rely x luting cement and nanocomposites after irradiation[13,14,15].

In the present study, the flexural strengths of two different composites were evaluated before and after irradiation with three doses of radiation 2kGy, 4kGy and 10kGy. The Flexural strength of Filtex Z350 XT before radiation was 172.5 MPa. The flexural strength of FiltexZ350XT after irradiation with 2kGy, 4kGy and 10kGy was found to be 285.45, 341.92 and 388.6 respectively. The p value was statistically significant ($p<0.001$) (Table 2). Flexural strength of Filtek Bulfill before radiation was155.26. Flexural strength of Filtek Bulfill after irradiation with 2kGy, 4kGy and 10kGy was found to be 206.74, 256.87 and 311. 85 respectively. The P value was statistically significant ($p<0.001$) (Table 2). A comparison of flexural strength between Filtex Z350 XT and Filtek Bulfill before and after radiation was also analyzed, where Filter Z350 XT showed better results (Graph 1).

The results advocated that the flexural strengths of the radiated samples were statistically significant as compared to the control samples. A positive correlation was found between the increase in the dosage of radiation with the increase in the flexural strength. The increase in flexural strength after electron beam irradiation can be attributed to the cross- linking and polymerization.

Cross-linking constitutes linking together long chains of polymers which in turn increases the molecular mass of the polymer. In this process, the chemical structure of the polymer gets altered. During the process of irradiation, free radicals are released which recombine for ming the cross links[5,6]. The degree of cross-linking varies depending upon the polymerization reaction and the radiation dose. The major advantage of cross-linking from electron beam irradiation is that the degree of cross linking is controlled by the amount of dosage of radiation[16].

The increased flexural strength may also be attributed to the polymerization reaction. Polymerization reaction is basically a chain reaction, which can be, explains as the number of double carbon links present in the monomers getting converted into single links to form the polymeric chain during the polymerization process called the degree of conversion[17,18]. The reactions of monomers in order to form a polymer is known to have an important effect on the physical and mechanical properties of composites resins[19,20,21,22].

Conclusion

Nanotechnology has brought about the advent a restorative material with increased polish ability, as well as excellent mechanical properties suitable for high stress bearing restorations. However, further *in-vitro* studies can be carried out to improvise on the mechanical behavior of Nano filled composites and in-vitro studies to determine their clinical performance.

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