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Comparative evaluation of the fracture resistance and microleakage of three different spherical filler containing composite resins – An in-vitro study

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Abstract

Aim: To compare and evaluate the fracture resistance and microleakage of three different spherical filler containing composite resins.

Methodology: Forty-five samples of different brands of spherical filled composite resin in cylindrical shape were prepared with the help of metallic moulds. Samples were divided into three groups of 15 samples each - Group I (n=15): Neospectra ST composite resin (Dentsply), Group II (n=15): Filtek Z350 XT (3M) and Group III (n=15): Estelite(Tokuyama Dental).Restorative materials were inserted in different moulds andcured with LED curing light.All samples were stored in distilled water for 24 hrs. Later, the samples were tested for fracture resistance.

For micro leakage standardized class V cavities were prepared on the buccal surfaces of 50 extracted permanent premolar teeth. The cavities were divided into three experimental groups (n=15 each group) and one control group (n=5) according to the resin composite material. Groups I, II&II were restored with Neospectra ST, Filtek Z350 XT and Estelite, respectively.The teeth were stained with methylene blue and then sectioned, and the extent of dye penetration was examined under a stereomicroscope for all the samples One sample from each group was later checked under scanning electron microscope (SEM) to confirm the findings of stereomicroscope.

Result: Highest mean fracture resistance and lowest microleakage score was observed in Group 1 containing

Neospectra ST followed by Group 2 containing Estelite Sigma and lowest fracture resistance & highest microleakage score was observed in Group 3Filtek Z350 XT.There was statistically significant difference between Group 1 & Group 3.

Conclusion: Within the limitation of this study, it can be concluded that Neo Spectra ST showed the maximum fracture toughness and minimum microleakage values.

Keywords: Microleakage, Spectra ST, Neospectra

Introduction

The composite resin filler size is only one of several parameters affecting the overall properties. The filler type, shape and amount, as well as the efficient coupling of fillers and resin matrix, contribute to the material performance (Khan et al., 1992)[1] . The combination of relatively small and varied size fillers allows a more dense packing, which in turn increases the possible filler volume-fraction of the resin- composites. Moreover, the spherical shape, especially in a mixture of different sizes, different geometrical forms facilitates incorporation of more inorganic fillers in the resin matrix . It also improves the fracture strength of the materials because stresses tend to develop preferably at sharp edges of the fillers (PradeepKumaret al., 2016)[2] .

Moreover, the spherical shape, especially in a mixture of different sizes, different geometrical forms facilitate incorporation of more inorganic fillers in the resin matrix. It also improves the fracture strength of the materials because stresses tend to develop preferably at sharp edges of the fillers.[3]

Recent materials with higher filler loading and spherical shaped fillers like Neospectra ST, Filtek and Estelite are introduced with improved physical and mechanical properties.

Therefore this study was done to compare and evaluate the fracture resistance and microleakage using Neospectra (nanoceramic), Estelite (supra nano composite) and Filtek Z-350 (nanocomposites),spherical filler containing composite resins.

The null hypothesis is that there is no difference in fracture resistance and microleakage between three different composite resins.

Methodology

For Fracture Resistance Test: Total of 45 cylindrical shaped specimens were prepared, 15 each from Neospectra ST composite resin(Dentsply); Filtek Z350 XT (3m) and Estelite(Tokuyama Dental) using a cylindrical plastic mould. Each specimen of 6mm in diameter and 3 mm in thickness was fabricated according to American Dental Association (ADA) specification no. 27.

Restorative procedure

Restorative material was inserted into mould in 2 increments of 1.5mm each with the help of a plastic filling instrument. A glass slab is placed over the mould after filling with the composite resin to get a flat surface. Each increment was cured using LED light curing unit having wave length of 375-400 nm and 800mW/cm^2 light intensity for 40 seconds. The accuracy of light curing unit was first checked by a radiometer.

The 45 samples so prepared were divided into groups as follows and subjected to experimentation.

Group I: Neospectra ST composite resin (Dentsply)

Group II: Estelite(Tokuyama Dental)

Group III: Filtek Z350 XT (3M)

After curing all samples were stored in distilled water for 24 hrs at 37°C.

Fracture Resistance Test:-

The fracture resistance of the teeth was measured using an Instron India universal testing machine (model 1011). Each specimen was subjected to compressive loading using a 5 mm round diameter stainless steel ball at a strain rate of 6 mm/min.

The force necessary to fracture the specimen was recorded in Newton (N), and data obtained were tabulated and subjected to the statistical analysis using IBM SPSS Statistics professional software**.**

For Microleakage Test

Fifty noncarious, intact human permanent premolar teeth were collected. The teeth were scaled and cleaned with tap water for surface debridement, polished with a rubber cup and pumice, and stored in distilled water at room temperature until they were used in the study. According to the type of resin composite, the teeth were randomly divided into three groups of 15 teeth each (n=15) and one control group (n=5). On the buccal surface of each tooth, Class V cavities were performed in the gingival one-third. The cervical margin was located 0.5 mm apical to the cementoenamel junction (on dentin/cementum). The cavities in the dentin were 2 mm in diameter and 2 mm in depth. Under a water coolant, a round diamond bur size BR-45 was utilized with a high-speed hand piece to standardize the cavity width. By inserting the full head of the bur, the cavity's depth was adjusted to 2 mm.

At any of the prepared cavity enamel margins, no bevels were produced. To eliminate dullness, a new bur was used for each cavity. One component etching system was used which was applied with a fully saturated microbrush with slight agitation to cover the entire surface and was gently air dried approximately 0.5 mm away from the prepared surface for 1–3 seconds, to allow the solvent to evaporate. The adhesive was then cured using a light curing unit (I Led,one cure woodpecker)which has high-power LED blue light, rechargeable battery with AC 100V–240V 50V with a light intensity of upto 2300mw/cm^2 for 20 seconds according to the manufacturer's instructions

Group I was restored with Neospectra (Dentsply), Group II was restored with Estelite(Tokuyama), Group III was restored with Filtek Z-350 XT (3M), A3 color shade was used for all types of composite resins.

To avoid composite sticking to the instrument, the restorations were placed in two increments using a plastic condenser and cured for 20 seconds according to the manufacturer's instructions. This was followed by thermocycling of teeth for 1000 cycles in a water bath at 5° and 55° C for 30 seconds.

The entire tooth surface was covered with two layers of nail varnish within 1 mm of the bonded interface and left undisturbed for one day to allow the varnish to dry.The apices of the roots were sealed using sticky modeling wax. Each tooth was then wrapped with aluminum foil, which was adapted using a ball burnisher. A window in the aluminum foil was cut so that the restoration and 1 mm around it was exposed using a sharp scalpel. A final coat of nail varnish was applied on the wrapped foil at the cut edges to ensure proper sealing.

Teeth were immersed in a freshly prepared aqueous methylene blue solution with a concentration of 2 gm/200 c.c water for 4 hours at room temperature.The teeth were then removed from the dye and rinsed completely and gently under running water for three minutes to remove any remaining color. The aluminum foil wrapper was removed, and any leftovers on the teeth were thoroughly cleansed. The teeth were vertically sectioned through the center of the restoration, by a cutting machine using a diamond disk in a buccolingual direction along their long axis to assess the microleakage at the cervical margins. The sections were then separated, and the tooth restoration interface was examined at the cervical margins under a stereomicroscope (Nikon Eclipse E600, Tokyo, Japan), at 45 X magnification interface

The following scoring criteria have been used:

0=No microleakage

1=Microleakage at the 1/3rd initial side of the cavity wall

2=Microleakage extending beyond the amelodentinal junction 3=Microleakage along the floor of the cavity

After the microleakage test, one specimen was selected from each group and the tooth hard tissue and restorative material interface were examined under scanning electron microscope (SEM) (Seron, Aura100, Scanning Electron Microscope, Tokyo, Japan) and photographed.

As the microleakage scores were ordinal variables, thus summarized as Means & Std Deviation.

Results

Data for all groups were collected and analysed statistically using SPSS 22.0 (IBM SPSS Statistics, SPSS Inc., New York,USA).

One-way ANOVA test revealed a statistically significant difference (P = 0.005) between the groups tested for fracture resistance. On intergroup comparisons, Post hoc Tukey test revealed that there is a statistically significant difference in mean fracture resistance between the Group 1 and Group 2.

Highest mean fracture resistance was observed in Group 1 containing Neospectra STfollowed by Group 2 containing Estelite Sigmaand least in Group 3Filtek Z350 XT.

Microleakage scores were subjected to non-parametric tests of significance for inferential statistics. The intergroup comparison of microleakage scores was done using Kruskal Wallis test, as the number of groups were more than two. The post hoc pairwise comparison was done using Mann Whitney U test. The level of significance was set at 0.05.

Post hoc pairwise comparison showed that the mean microleakage score was found to be the minimum for Gr 1 (Neospectra ST), followed by Gr 2 (Filtek Z350 XT) & Gr 3 (Filtek Z350 XT) samples in increasing order, but only Gr 1 & Gr 3 showed a statistically significant difference.

Discussion

One of the cardinal requirements for the better prognosis of restoration is to prevent the microleakage, which is achieved with the proper adhesion of restorative material to the cavity walls. The inability of the restorative materials to attain the complete marginal seal leads to the occurrence of microgaps in which the seepage of fluids, ions, and bacteria occurs, which causes secondary caries, hypersensitivity, and pulpal infection.These are the most common reasons to replace or repair an adhesive restoration.[4] The microleakage is used as criteria by which researchers and clinicians can predict the performance of a restorative material.[8] The need for restorative material with better adhesive characteristics leads to the more recent advances in the restorative materials.[5]

Dye penetration assay was the technique used in this study. Methylene blue was used as the dye in our study, since it can diffuse easily through the interface, easily detectable and it is not absorbed by dentinal matrix hydroxyapatite crystals. As its having a lower molecular weight, it has high penetrability and penetrates the voids better than isotopes.[4]

The morphology of Class V cavities with margins partly in enamel and partly in dentin/cementum presents a challenging condition for the restorative materials. Class V cavities were selected for this study because of its configuration or “C” factor. The “C” factor of Class V restoration is 5, which is the reason for the internal bond disruption as well as microfissures around the restorations and cavity walls, so microleakage is more important in Class V cavities because of this high C factor.[6]

Therefore in the present study microleakage was assessed between tooth and restoration interface in a Class V composite restoration.

Fracture is a complete or incomplete break in a material resulting from the application of excessive force. Fracture resistance is directly related to the stoppage of the crack propagation.[7]

Masticatory forces have a tendency to deflect cusps, and composites decrease the deformation of the cusps under masticatory load.[8] The variation in strength between different composites may be explained due to the differences in the chemical composition of their matrix, filler content, filler size, and distribution. [9;10]Thus, a reduction in size and increase in the volume of fillers are directly proportional to an increase in compressive strength.[10,11] High filler loading increases the physical and handling properties of the composites, new adhesive materials not only seal the margin but also increase the retention and resistance properties of the restored tooth.[12] Recent nanofiller technology with nanometric fillers impregnated in nanoclusters leads to high filler loading resulting in an increase in high compressive strength. [13,14]

Therefore, present study was done to evaluate the fracture resistance and microleakage using Neo Spectra ST (nanoceramic), Estelite (supra nano composite) and Filtek Z-350 (nanocomposites), spherical filler containing composite resins.

In this study the null hypothesis was rejected as there was difference in microleakage and fracture resistance values between all the tested restorative materials.

In the present study group I (Neo Spectra ST) showed the least microleakage and highest fracture resistance among the three groups which can be attributed to the fact that Spectra ST is a nano-hybrid composite with pre-polymerized fillers. The filler system of Neo Spectra ST composite is a blend of spherical, pre-polymerized Sphere TEC® fillers (d3,50≈15 µm), non-agglomerated barium glass and ytterbium fluoride which could have increased the fracture toughness of the composite. Also, the resin matrix contains highly dispersed, methacrylic polysiloxane nano-particles, which are chemically similar to glass or ceramics which provides strength. Since SphereTEC® fillers allow the maximization of filler load (78-80 weight-% or 60-62 volume-%) in a composite by using primary particles of < 1 µm only. This could have resulted in less polymerization shrinkage causing less leakage.[15]

To the best of our knowledge no study has been performed till date to compare the fracture toughness of Neo Spectra ST compositewith the other two materials used in this study.

Although Estelite sigma (Tokuyama) had higher filler loading (82% by weight) compared to Neo spectra ST (Dentsply) (78-80% by weight) but the structural arrangement of fillers in Neo spectra provided better fracture toughness and less microleakgewhich could be due to its structural arrangement.

According to a study by Huan lu et al Estelite performed similar to nano-composite(Filtek supreme) and microhybrid composites(Tetricceram) in mechanical properties and generalized wear resistance when compared with other composites.[16]

Because the average particle filler size of Estelite Sigma Quick is 200 nm, it is considered a supranano-fill composite. The low volumetric shrinkage i.e. 1.3% reduces marginal leakage and stress on the restoration-tooth complex.[17] This could be the reason for low microleakage in Estelite Sigma Quick group than Filtek

Z350. Also presence of supra nanofillers (0.2-μm) mono-dispersing spherical filler (Si-Zr) wherein particle diameters of 0.2 μmin Estelite Sigma Quick are known to produce the best balance of material property such as fracture toughness

In the present study Filtek Z350 XT showed the lowest fracture toughness and highest microleakage even after the claim from manufacturer that Filtek™ shows lower polymerization shrinkage and higher filler loading.

Conclusion

Within the limitation of this study, it can be concluded that Neo Spectra ST showed the maximum fracture toughness and minimum microleakage values.

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