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Influence of In-Office and Home Bleaching Regimen on Flexural Strength of Nano-Hybrid Composite Resins: An In-Vitro Evaluation

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Significance: *Bleaching with 10%CP and 35% HP does not reduce the flexural strength of the nano-hybrid composite material tested. Thus, no replacement of restorations is required after these bleaching protocols.*

Abstract:
Objectives: *The aim of this in vitro study was to evaluate the effect of home bleaching (HB) and in-office bleaching (IFB) agents on the flexural strength of nano-composite resin after single and multiple exposures.*
Methods: *50 bar shaped samples were fabricated using nanohybrid composite resin and divided into 3 groups: home bleaching Group – 1 : Control group(n=10) placed in artificial saliva for 14 days, Group – 2 (n=10) bleached using home bleaching agent for 14 days and Group – 3 (n=10) bleached using in-office bleaching agents. Each of the experimental groups were further subdivided into 2 subgroups(2A,2B,3A & 3B) (n=10 each) based on the number of bleaching exposures such that subgroup-2A& 3A are exposed to bleaching agents once, whereas 2B & 3B are exposed for multiple times for 2 weeks and 3 weeks respectively. After bleaching treatment, a three-point bend test was performed using a universal testing machine, and flexural strength values were calculated. The data were analysed by statistical analysis.*
Results: *The differences in the Flexural Strength values between the bleached and the control samples for the Nano-Hybrid composites were not statistically significant (p=>0.005).*
Significance: *Bleaching with 10% Carbamide Peroxide (CP) and 35% Hydrogen Peroxide (HP) does not reduce the flexural strength of the nano-hybrid composite material tested. Thus, no replacement of restorations is required after these bleaching protocols.*

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I. Introduction

Esthetics is defined as "the science of beauty, that particular detail of an animate or inanimate object, that makes it appealing to the eye." The perception of an esthetic smile can be altered by various factors such as shape, form, texture, position and colour of the teeth by various treatment protocols and restorative techniques, such as direct or indirect veneers, ceramic crowns or with bleaching that can lighten the colour of teeth.[1]

Based on differences in application modes, whitening agents used, their concentrations, application periods, product ingredients and activation methods, several dental bleaching protocols have been described in the literature of which three major bleaching approaches include over-the-counter whitening products, dentist-supervised at-home bleaching agents, and in-office or power bleaching.[2]

During the in-office technique high concentrations (30-35%) Hydrogen peroxide (HP) or Carbamide Peroxide (CP) applied on tooth surfaces for a shorter duration (20-30minutes) whereas, in at-home bleaching technique, 10-16% Carbamide peroxide for 4-8 hours daily is made in contact with the teeth for 2-4 weeks using a custom fabricated tray for the patient.[3,4]

During clinical practice, tooth-coloured restorations exist in the teeth, that are planned to be bleached.[1] Unintended application of the bleaching products on teeth of patients with existing restorations cannot be excluded. Thereby, not only the mechanical properties but also the physical properties of the filling material affects the prognosis and longevity of restorations.[5]

Many studies investigated the possible effects of bleaching agents on various restorative materials which showed changes in colour, physical properties and their surface morphology[6] and reported conflicting results. Compared to inert metal or ceramic restorations, presence of organic matrix in composite resins make them more prone to chemical alteration.[5]

Flexural strength (FS) is defined as the failure stress of a material as measured in bending. It is generally considered a meaningful mechanical property for brittle materials that are much weaker in tension

than in compression. Clinically composite restorations can be subjected to considerable flexural stresses. Therefore, in class I, II, III, and IV restorations, where there are significant stresses, high FS would be desirable to resist deformation.[7]

So, the current study was aimed to evaluate the effects of 2 different bleaching regimens on the flexural strength (FS) of nano-hybrid composite resin at varying number of exposures.

OBJECTIVES:

- To evaluate the flexural strength of composites after its exposure to bleaching agents.
- To compare the flexural strength changes after home bleaching and office bleaching.
- To compare the changes in flexural strength after one and multiple exposures to bleaching agents.

II. Material And Methods

SPECIMEN PREPARATION: A nanocomposite resin (Tetric N Ceram, Ivoclar/Vivadent, Schaan, Lichtenstein) was used to prepare 50 bar-shaped composite specimens using a custom made split metal mould with 2 × 2 × 25mm dimensions, according to ISO 4049 specifications. Composite resin was filled in the cavities of the moulds against a glass slide placed at the bottom of mould space, and another glass plate was then placed over it, and pressure was applied to extrude excess material and was light polymerised at an intensity of 850mW/cm² - 1000mW/cm² for 40 seconds to ensure adequate polymerisation as shown in Figure-1.

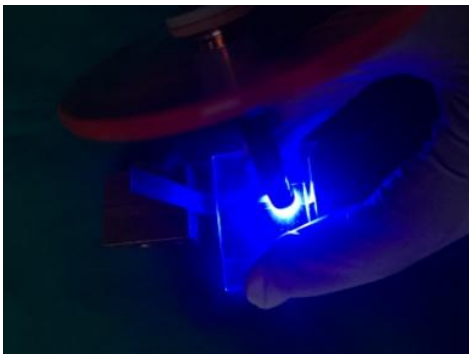


FIGURE-1 Preparation of nano-hybrid composite test specimen using a split metal mould

All surfaces of the specimens were painted with nail varnish, except one flat surface that was near to the curing light. The specimens were then placed in artificial saliva for 24 hours at 37°C, after which they were divided into 4 groups (n=10).

BLEACHING PROCEDURE:

GROUP – 1 (n=10): [CONTROL GROUP] – Nanohybrid composite bars immersed in artificial saliva [Wet Mouth, ICPA Laboratories, India] for 2 weeks. (Figure-2A)

GROUP – 2 (n=20): [HOME-BLEACHING GROUP] – Nanohybrid composite bars that were bleached using a commercially available Home Bleaching agent (Whiteness Perfect, FGM, Joinville, Brazil) according to manufacturer's instructions.(Figure-2B) They were further subdivided into 2 groups based on the duration of bleaching.

2A (n=10): Test samples exposed to home bleaching agents for one time (4 hours)

2B (n=10): Test samples exposed to home bleaching agents for 14 days (3-4 hours/day)

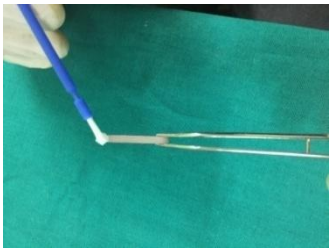
[A]  [B]  [C] 

FIGURE: 2 [A]Control specimen placed in artificial saliva, [B] Application of, [C] Application of office bleaching agent (35% Hydrogen Peroxide) using a brush home bleaching agent (10% Carbamide Peroxide) using an applicator tip

GROUP – 3 (n=20): [IN-OFFICE BLEACHING GROUP] – Nano-hybrid composite bars that were bleached using a commercially available In-office bleaching agent (Florence, Prevest Dentpro, Jammu, India) according to manufacturer's instructions.(Figure-2C) The samples were further subdivided into 2 groups based on the duration of bleaching.
3A (n=10): Exposed to in-office bleaching agents for one time (30mins)
3B (n=10) : Exposed to in-office bleaching agents for 3 weeks (20-30 mins/ week)

FLEXURAL STRENGTH EVALUATION:
A three-point bending test was done using a Universal Testing Machine (Instron, Model no.5566) with a crosshead diameter speed of 0.5mm/min. The force will be applied until fracture was observed in the specimens, as shown in Figure-3.

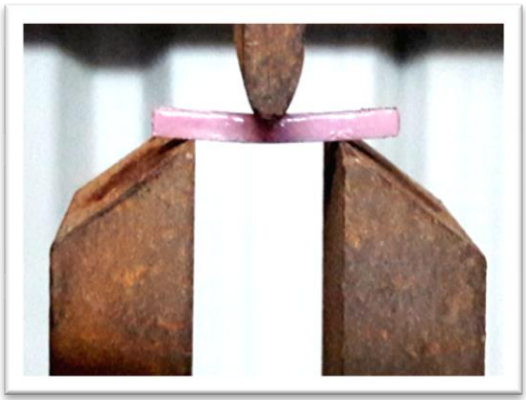


FIGURE- 3 Three-point bend test done to evaluate the flexural strength of the test specimen

The FS (σ) values (MPa) will be calculated using the following equation:

$$\sigma = 3FL / 2BH^2$$

Where F is the failure load (N),
L is the distance between the jig supports(15mm),
B and H are the width and height of the specimen, respectively(2mm).

Statistical analysis:
Data were analysed using SPSS version 23. Descriptive analysis and Mann Whitney U test were performed for intergroup comparison of Flexural Strength values.

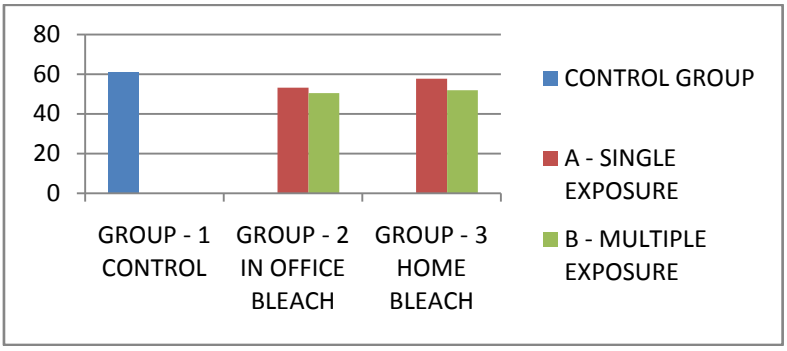
III. Result

TABLE: 1 DESCRIPTIVE STATISTICS OF MEAN VALUES OF THE STUDY GROUPS

	N	MEAN	MAXIMUM	MINIMUM	STANDARD DEVIATION
GROUP – 1	10	60.75	72.00	56.00	1.538
GROUP – 2A	10	53.30	69.00	32.00	1.252
GROUP – 2B	10	50.48	72.00	30.00	1.561
GROUP – 3A	10	57.80	72.00	41.00	1.250
GROUP – 3B	10	51.89	72.00	38.00	1.266

The mean flexural strength values and their standard deviation of the study groups were given in Table-1 and Figure - 4.
The results show that the control group had greater flexural strength than the experimental groups that were exposed to bleaching showed a slight decrease in their mean flexural strength. When statistically analysed, the differences in the values were insignificant as the p-Value was greater than 0.05.

FIGURE – 4: GRAPHICAL REPRESENTATION OF MEAN VALUES OF STUDY GROUPS



Mann Whitney U- test was performed for intergroup comparisons which showed no significant differences between the study groups.

IV. Discussion

The present study attempted to evaluate the effects of home and office bleaching regime on the flexural strength of nano-hybrid composites.

Flexural strength, by definition is, "the failure stress of a material as measured in bending, is generally considered to be a meaningful mechanical property for brittle materials that are much weaker in tension than in compression."[8]

Due to the dynamic nature of forces that exist during mastication, flexural strength test was considered as a valuable tool to be evaluated, as it is a combination of all kinds of stresses that act simultaneously on teeth and this mechanical property was related to clinical performance of restorative materials under the stress of functional and parafunctional biting forces, especially for brittle materials such as composite resins. In stress-bearing situations, high flexural strength is desired to withstand biting forces without fractures.[9]

Several methods such as flexural three-point bending, double torsion mode indentation test and compact tension test are widely employed in dental research to determine the flexural strength of a restorative material.[9]

In the current study, three-point bending test was performed, based on the International Organization for Standardization (ISO) specification 4049/2008 for polymer-based restoratives[10] and it had a lower standard deviation, coefficient of variation, and the less complex crack distribution. Hence it was considered as an appropriate choice for measuring FS of the study samples.[8]

The results of the study showed no significant changes in the FS of nano-hybrid composite resins after exposure to home and office bleaching agents after single and multiple exposures.

The adverse effects of bleaching procedure were not observed in flexural strength tests, because of the resistance of the chemical bonds of silane coupling agents in the composite resin to the oxidative cleavage induced by peroxides in bleaching agents. The short period of exposure of the test specimen to bleaching agents could have accounted for the resistance of composite resin.[11]

Similar results were obtained by Firoozmand et al.,(2009) who reported that there was no change in flexural strength of hybrid composites after exposed to bleaching regimen.[9] In a study on the influence of Carbamide Peroxide on the flexural strength of various tooth-coloured restorative materials at different environmental temperatures, Yu et al. (2010), concluded that composites resins and ceramics remained stable even after its exposure to bleaching agents.[8] However there was an increase in flexural strength of hybrid composites as stated by Feiz et al. (2018), after its exposure to home bleaching agents.[12]

In the present study, the restorative materials were placed in a custom made Split metal mould of dimensions (25mm*2mm*2mm) which ensured standardisation of the shape and size of each specimen. The restorative material was covered with matrix strips on both sides of the mould space which eliminates early moisture contamination of restorative material and was held under constant hand pressure using glass slides on either side to remove excess material and to obtain matrix finished smooth surface.[13]

Patients seeking bleaching treatment may have teeth restored with different kinds of esthetic restorative material, thus contact also occurs between the bleaching agent and pre-existing restorations, with the latter being exposed to the same condition. It is possible that chemical softening, resulting from bleaching, may affect the clinical durability of these materials. The interaction between the bleaching agent and restorative material is of clinical significance.[14] Changes in the chemical and morphological structure of restorations must be of concern when bleaching is used as a whitening treatment.[13]

Peroxides from the bleaching agents diffuse and generates free radicals that cause oxidation and reduction reaction. These peroxides may induce oxidative cleavage of polymer-chains causing softening of resin

matrix of composite resins and the unreacted double bonds being the most vulnerable parts of the polymers. Furthermore, free radicals may impact the resin-filler-interface and cause a filler-matrix debonding, creating microscopic cracks.[10]

The adverse effects of bleaching procedure were not observed in flexural strength tests in this study, because of the resistance of the chemical bonds of silane coupling agents in the composite resin to the oxidative cleavage induced by peroxides in bleaching agents. There is a need for prolonged contact of the bleaching agent to allow the oxidative damage and thus the short period of exposure of the test specimen to bleaching agents could have accounted for the resistance of composite resin.[11]

Clinically relevant bleaching regimens that followed manufacturer's recommendations were adopted for the current study, in contrast to several other bleaching studies in which materials were exposed continuously to bleaching products for several days to simulate cumulative effects over a time period (Monaghan, Lim & Lautenschlager, 1992; Cullen & others, 1993).[5]

The bleaching protocol in the present study was designed to simulate treatment of teeth under cycling conditions of bleach and saliva exposure which is encountered under in situ conditions. Moreover, saliva may help to wash out peroxides from the surface.[2]

Finally, it should be taken into account that clinically relevant bleaching treatment protocol was followed in the current study. Studies that evaluate more intensive bleaching protocols, such as the combination of both home bleaching and in-office bleaching, or in association with light and heat activation, should be conducted, which may enhance the adverse effects of the bleaching agents over the mechanical strength of composite resins.[11]

V. Conclusion

On the basis of results of the current in-vitro study within its limitations, it can be concluded that using tested home bleaching agent and in-office bleaching agents had no remarkable effect, neither to increase nor to decrease when compared to control group on the FS of tested composite resin.

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