Comparative evaluation of bond strength of fibre posts to composite core after surface treatments with Er,Cr:YSGG laser, Diode laser and Sandblasting - *an invitro study*3.

- **First author**- Dr Ankita Singh, BDS MDS
  Senior Lecturer, Department of Conservative Dentistry and Endodontics, Manipal College of Dental Sciences (MCODS), Mangalore

  Institutional Affiliation- Manipal Academy of Higher Education (MAHE), Manipal

  Orchid id-0000-0003-1524-7834

  ankita200393@gmail.com

- **Second author**- Dr K Harish S Shetty, BDS MDS

  Professor, Department of Conservative Dentistry and Endodontics, Yenepoya Dental College, Mangalore

  Institutional Affiliation- Yenepoya University

  shettyharish@gmail.com

- **Third author**- Dr Prathap M S, BDS MDS

  Professor and Head of the Department, Department of Conservative Dentistry and Endodontics, Yenepoya Dental College, Mangalore

  Institutional Affiliation- Yenepoya University

  prathapmsnair@gmail.com

- ***Fourth author and Corresponding author**- Dr Vinod Jathanna, BDS MDS
  Associate Professor, Department of Conservative Dentistry and Endodontics, Manipal College of Dental Sciences (MCODS), Mangalore
  Institutional Affiliation- Manipal Academy of Higher Education (MAHE), Manipal

5. The name of the department(s) and institution(s) to which the work should be attributed : Department of Conservative Dentistry and Endodontics, MCODS, Mangalore-Manipal Academy of Higher Education (MAHE)
6. The name, address, phone numbers, facsimile numbers, and e-mail address of the contributor responsible for correspondence about the manuscript:

Corresponding author : Dr Ankita Singh

C3-4A, RNE KMC Staff Quarters, Light house hill road,

Mangalore, Karnataka 575001, India

8884768808

ankita200393@gmail.com

Orchid id-0000-0003-1524-7834

INTRODUCTION:

Endodontically treated teeth are often weakened by caries, excessive wear, or several repeated restorations, and because of this lack of tooth structure have lower fracture strengths than sound teeth. [1] These teeth require further reinforcement to improve the retention and long term clinical success of the restoration and hence pose a frequent challenge to clinicians around the globe.

This need for reinforcement paved the way for the introduction of varied post and core systems. The intra-radicular posts are essential to obtain a core for a long standing restoration to reconstruct any tooth structure loss.

The beginning of the 1900s saw the introduction of the Prefabricated glass fiber-reinforced composite (FRC) posts and in particular the carbon-fiber posts. [2] The continuous demand for aesthetics required the development of glass or white-quartz fibers and translucent resinous matrices.

FPs are mostly composed of a polymeric epoxy or methacryate based resin matrix reinforced with carbon, quartz, zirconia, glass or silica fibers with a high degree of conversion and cross- linked structures. [3] Prefabricated fiber posts gradually gained popularity in comparison to the older cast posts to provide retention for the core in permanent restoration of root filled teeth. The popularity of these prefabricated fibre posts is because of their biocompatibility, resistance to corrosion, optical properties, mechanical strength, shorter treatment visits and the overall elimination of any laboratory steps. [4, 5] Their metal free composition also allowed easy removal if necessary. [6]

Furthermore, the similarity of the posts' elastic modulus to dentin has been proven to significantly reduce the risk of vertical root fractures in endodontically treated teeth. [4] Glass fiber posts have been reported to exhibit high fatigue strength, high tensile strength and have higher survival rates in case of intermittent loading. [7] These posts distribute occlusal stresses more evenly in the root dentin leading to less catastrophic root fractures.[2]

Among core materials, glass ionomers, resin composites, amalgam, and cast metal alloys have been frequently used. Resin composites have several advantages as compared to other restorative materials, making them an obvious choice for core buildup among dentists. Composite resins show strength comparable to amalgam and with better bond strength to dentine. [8].Their similarity to tooth structure in hardness and fracture toughness and aesthetic results under all-ceramic crowns further make them the material of choice. [8].

The longevity and success of post and core restorations depends on various factors such as, the type of post, the material of the core and the quality of bond between the post, core, luting cement and dentin. [9] Keeping the need of superior material properties in mind, the combination of prefabricated posts with resin composite cores can be expected to yield a more homogenous and aesthetic appearance to the final restoration.

Despite the several aforementioned advantages of these fibre posts over conventional posts, the bonding achieved to the core material and the root dentin has always been a cause for concern. Laboratory and clinical research has found that the most common cause of clinical failures of fibre posts and composite core systems is the adhesion failure through decementation between the fibre post-resin and/or resin-root canal dentine interfaces. [10] If bonding at any of these interfaces is poor, debonding and/or fracture of the post and core can occur. Therefore, good adhesion of these interfaces is quintessential for a successful fibre post restoration.

In an attempt to improve the bonding, particularly between the fibre post and the composite core, different post surface treatments have been suggested. These surface pretreatment strategies aim to make changes to the matrix of the fibre posts to improve the potential surface energy of the posts thereby increasing their bonding ability to composite cores and root dentin. [3]

Since the polymeric matrix of the surface of glass fibre posts does not chemically react with the resin monomers, roughening strategies can expose the fibers. This leads to the creation of micro-retentive areas, increasing the surface area for bonding and there by leading to an improvement in bonding between the surfaces. [11] The penetration of resin in these porosities can lead to mechanical locking to the core material. Some surface treatments may also lead to the removal of the superficial layer of the resinous matrix, enhancing chemical bonding to restorative materials. [12]

The possibility of improving bonding between the posts and core materials has led to the investigation of various chemical and mechanical surface treatment procedures throughout the years. These procedures range from the use of chemicals like hydrofluoric acid, hydrogen peroxide, phosphoric acid, methylene chloride and silane to mechanical procedures like airborne particle abrasion, tribochemical coating systems and laser irradiation. [6]

The recent advent of laser technology in the field of dental science has provided many applications. Caries removal, tooth bleaching, treatment of hypersensitivity and soft tissue surgical usages are but a few of the applications of lasers. [3] With regards to their usage for surface treatments of fibre posts, there is a lot of controversial data surrounding its usage. Literature is divided in its stance on the effect of lasers on the bond strength of posts to core material.

Throughout literature various laser wavelengths have been used to experimentally improve the bonding between restorative materials. [11] They have shown to change the wettablility characteristics of metals and ceramics to aid in adhesion and bonding. [4]

Arslan et al reported that Er:YSGG laser irradiation was more effective than sandblasting for increasing the bond strength of fiber-glass posts to composite core while Tuncdemir et al showed that Er:YAG laser irradiation had no significant effect on the bond of quartz fiber posts to resin cements. [1] These controversial results beg further investigation of the application of Er:YSGG lasers specifically in surface pretreatments.

Diode lasers on the other hand have shown to modify dentin topography and increase the bond strength of posts to root dentin. [13] Since not a lot of literature is available on the use of these compact and low cost systems in post surface treatment, this study aimed to investigate their role.

Sandblasting treatment of fibre posts for improving the bond strength to core materials has been widely investigated. This technique is intended to remove the top layer of resin and render the glass fibers suitable for chemical interaction. [1] The bonding to restorative materials is improved because of micromechanical interlocking and increased retention to core materials. [1] Since surface roughness is inevitable with this technique, it is one of the most frequently used surface pretreatments.

In contrast to these claims, some authors have reported sandblasting to be an aggressive procedure which might lead to undesirable changes in the mechanical and physical properties of fibre posts. [6]
Many factors like functional loading, thermocycling and penetration of oral fluids in the interfaces between the materials can have a role on the retention between the posts and composite core. [14] Thermocycling and water storage are frequently used techniques to induce artificial aging. Thermal changes induced by thermoclycling have shown to degrade the physico-chemical properties of composite and compromises its bond to posts. [1] Water storage has also shown to negatively affect the bond within and on the surface of composite thereby compromising its bond strength. [14] These in-vitro aging simulations of oral conditions are essential to induce results similar to a clinical setup.

Since there isn't a definite surface treatment protocol to improve bonding between fibre posts and composite cores, this study sought to assess the effect of Er,Cr:YSGG laser, Diode laser irradiation and sandblasting on push-out bond strength of fiber post to composite core, in comparison with no surface treatment. It was hypothesized that there would be no difference in the bond strength of composite core to fibre posts after surface treating the fibre posts with either Er,Cr:YSGG laser, Diode laser or Sandblasting.

- **Methods:**

Inclusion criteria**:**

- Glass fibre posts.

Exclusion criteria:

- Fractured glass fibre posts.
- Surface irregularities on fibre posts.

In this in-vitro study 28 fibre posts of 1mm diameter and 20mm length (ANGELUS REFORPOST Fibre Post Glass X-ray Refill) were used. All of the fiber posts were washed with ethanol 96% and air-dried.

Based on the method of surface treatments, the posts were randomly divided into 4 groups.

Division of Groups:

- Group A: Control group (No surface treatment). (n=7)
- Group B: Fibre posts surface treated with Er,Cr:YSGG laser. (n=7)
- Group C: Fibre posts surface treated with Diode Laser. (n=7)
- Group D: Fibre posts surface treated with aluminum oxide particles. (n=7)

Surface Treatments:

- Group A

This is the Control group, hence no surface treatments were done.

- Group B

A Er,Cr:YSGG laser (Biolase,Waterlase iPlus) with a 2790nm wavelength was used for the surface treatment. A MZ5 Zircon, 500 μ diameter tip was used. The laser was set at a power of 1 W with 20Hz frequency, 60% water and 40% air. The posts were lased longitudinally in a sweeping motion for 40 seconds for 2 cycles with a 10 second gap. The distance of the tip of the laser to the post was 1mm and was incident at a 90˚angle.

- Group C

A Diode laser (EZ Lase,Biolase) with a 940 nm wavelength was used for the surface treatment. The laser was set at a power of 2W and was used in a pulsed mode. The pulse interval was 1ms with a pulse width of 0.1ms. A 200 μ diameter tip was used. The posts were longitudinally divided into 4 segments and each segment was lased for 40seconds.The average power delivered was 0.18W and the energy delivered was 8J. The distance of the tip of the laser to the post was 1mm and was incident at a 90˚angle.

- Group D

Sandblasting of the fibre posts was done with 50 μm Aluminum oxide particles (Korox 50, Bego, Bremen, Germany) at 40 psi for 10 seconds. It was performed with overlapping sweeps holding the nozzle 10 mm from the surface of the post.

Specimen Preparation:

Following surface treatments, all the fibre posts were rinsed with saline and gently air dried. Universal bonding agent (Tetric N Bond,Ivoclar Vivadent) was applied on the entire surface of fiber posts, gently air dried and each surface was cured for 20 seconds using a light curing unit (Bluephase C8, Ivoclar,Vivadent) with a light intensity of 1200 mW/cm2.

Custom made plastic moulds with an internal diameter of 10mm and a demarcated hole at the centre of the base were used. The hole was made to standardize the central position of each post in relation to the mould. The non-tapered side of each fibre post was stabilized with low fusing wax (Sticky wax) in the demarcation of the mould.

After post placement, Dual cure composite (Paracore,Coltene) was inserted to the mold in 2 mm increments and was cured for 20 seconds using the same light curing unit. The procedure was continued until the non-tapered zone of each post was completely covered and the mould was filled. Next, the remaining tapered part of each post was cut.

After 30 min, the mold was sectioned with a scalpel blade to remove the specimens, and an additional 40 sec of light-curing was performed to ensure optimal polymerization of the resin core material. This resulted in a cylinder of resin core material that was built up around the fiber posts.

For artificial aging, the specimens were subjected to thermal cycling (5000 cycles, 5°–55℃, 30 sec dwell time) in a Thermocycling unit. Before the sectioning procedure, all specimens were stored in distilled water for 24 h.

After 24 h of storage in water, specimens were attached to a metal arm and sectioned with a hand held saw, perpendicular to the bonded interface into 2 mm thick segments under water. Four segments were obtained from each post-and core specimen.

The exact thickness of each post-and-core segment was measured using a digital micrometer (Mitutoyo, Tokyo, Japan).

<u>Evaluation of Bond Strength:</u>

The total bonding area of each FRC post segment was calculated using the formula: A=2 * π* r* h, where r is the post radius, P is the constant 3.14, and h is the thickness of each post section. The bonding area was equal for all post segments and was calculated to be A=2 * 3.14* 0.5* 2 which is 6.28 mm^2.

Specimens were mounted in a Universal Testing Machine. The discs were loaded with a flat ended cylindrical plunger, 1.0mm in diameter, centered on the disc avoiding contact with the surrounding core surface, with a cross-head speed of 1.0mm/min. Load was applied in an apical-coronal direction until the post displacement occured. Maximum load at post displacement was measured in Newton and calculated and reported in MPa according to the formula:

Debonded Stress (in MPa)= Debonding force at failure/Bonding Area

Where the Bonding area was $6.28mm^2$

- **Ethical issues:** There were no ethical issues in this study
- **Study Design:** In Vitro quasi experimental study.
- **Statistical analysis:**
- Collected data was analyzed by both descriptive and inferential statistical methods. Descriptive methods such as mean and standard deviation were obtained to summarize the data of parameters in each group.
- Inferential methods such as One-way analysis of variance (ANOVA) were used to evaluate the effects of surface treatment procedures on the bond strength between FRC posts and composite core material. Post hoc Bonferroni test was also performed to evaluate the statistical significance between the groups. The mean and standard deviation (SD) of push-out bond strength of fiber posts to composite core were reported for the four groups.
- Level of significance was 5% and analysis was performed in statistical software (SPSS for Windows, version 23.0).

- Results:

Mean push bond strength was higher in Sandblasting group (24.60 ± 2.562) followed by control group (23.92±4.695). ANOVA test was applied to compare the push out bond strength among the groups. ANOVA test showed no statistical significant difference among the groups ($p=0.29$) with respect to push out bond strength. Post hoc Bonferroni test showed no statistical significant difference between the groups.

- **Discussion**

Within the limitations of this study, it was concluded that the hypothesis proposed was partly rejected. There was an increase in the bond strength of fibre posts to composite core material after subjecting the posts to Sandblasting treatment, although the increase was not significant. However, Er,Cr:YSGG and Diode laser irradiation had no effect on the bond strength as compared to the Control and Sandblasting groups.

The nature of the interfaces between the fibre post and the composite core, the luting cement and the core, and the luting cement and the root canal dentin is crucial for the clinical success of a post and core restoration of an endodontically treated tooth. The durability of these interfaces is imperative to efficiently transfer stresses under functional loading. [30] If bonding at any of these interfaces in poor, debonding or fracture of the post and core restoration can occur. [31] This study aimed to evaluate the methods to improve the bond strength between one of the above mentioned interfaces, i.e. the fibre post and the composite core.

To obtain a bond between the resin matrix of the fiber post and the methacrylate-based resin of the core material, fiber posts must be subjected to mechanical or chemical surface treatment.

In the current study the samples were prepared using Er,Cr:YSGG laser, Diode laser and sandblasting technique using Aluminium oxide particles.

The results of the study showed that that the mean value of push-out bond strength of fiber posts to composite core following 1 watt Er,Cr:YSGG laser, 2 watt Diode laser and Sandblasting were 22.43 ± 3.69, 20.30 ± 3.374 and 24.60 ± 2.562 respectively. This was in contrast to 23.92 ± 4.695 for the Control group, which had no surface pretreatments of the post.

It has been documented that chemical composition (type, size, distribution and percentage of fibers) and surface topography of posts affect the post-resin core bond strength. [8] In this study, only one type of Glass Fibre Post (Reforpost, Angelus) was used to assess the effect of different surface treatment protocols on the pushout bond strength to composite core. This ensured standardization in the type and composition of fibre post.

In the current study, the sandblasting group value for push out bond strength was higher as compared to all the other groups (24.60 ± 2.562). This result is consistent with those of previous studies that reported that airborne particle abrasion and sandblasting with Alumina particles increased the surface area, surface roughness and enhanced the mechanical interlocking between the cement and roughened surface of a post. [1, 2, 4, 6] The composition of the glass fiber surface is composed of resin matrix, inorganic filler particles and glass fibers. [32] The removal of the superficial layer of the resinous matrix due to the mechanical action of the sandblasting particles may probably be the reason for the creation of the microretentive spaces on the surface of the post. [2] Some authors are of the opinion that sandblasting modifies the epoxy resin matrix and creates a larger surface area aiding bonding. [9] Resin penetrates into the microporosities and forms resin tags, which result in micromechanical interlocking thereby enhancing the retention of the core material. [1]

Mechanical pretreatment of FRC posts with sandblasting roughens the FRC post surface; yet, in addition to the matrix being removed, the fibers which are exposed in the process might also be damaged, depending on the particle size and abrasion time. [2] It has also been reported that sandblasting protocol causes cracks in the fibre post and modifies the shape of the fiber post eventually compromising post fit and reducing the strength of the post. [25, 33, 34] In a study conducted by Hashemikamangar et al [1], SEM micrographs revealed irregular dugout areas of resin matrix all over the surface of the fiber posts.

Several factors are responsible for increasing the surface roughness of the post with Al_2O_3 particles like particle size, air pressure, abrasion distance, and abrasion time. [25] Since literature has reported a variety in these parameters, a standard protocol for this technique has not been made concrete.

To minimize any dimensional changes in the post and to prevent crack propagation, mild sandblasting was performed in this study by using 50µ Al_2O_3 particles at 40 psi for 10 seconds. It was performed with overlapping sweeps holding the nozzle 10 mm from the surface of the post.

These parameters were similar to a study conducted by D'Arcangelo et al [35] to increase the post's mechanical retention without decreasing their flexural properties.

Most studies have reported an increase in the bond strength and the retention of sandblasted fibre posts to endodontically treated teeth and core material , however there have been studies which report little effect on bond strength or that the bond strength was actually reduced. [36] Since the current study showed an increase in the bond strength, although not very significant in value, it can be concluded that this treatment can prove to be beneficial with further investigation into the different parameters. An investigation with SEM analysis and Laser Confocal Microscopy into the quality of surface roughness achieved is warranted to come to a favorable sandblasting protocol.

In addition to sandblasting surface pretreatments, other methods have been tested to overcome the reduced reactivity of the FRC post surface. One of the recently introduced techniques of surface treatment of post is laser irradiation. [27]

Lasers have shown to increase and improve the bond strength of dental materials because of an alteration in their wettability. [13] Ablation caused by laser depends on the nature of the primary absorber and the substrate microstructure. [13] The ablative effect is related to the conversion of laser light energy into heat. Hence the water content and other surface elements influence the capacity of absorption. [13]

Authors have suggested that the energy delivered by the lasers is absorbed by the hydroxyl groups in composite materials such as fibre posts, causing ablative effects to the organic matrix thereby increasing the surface roughness by matrix removal. [3]

Laser irradiation, particularly with Er,Cr:YSGG laser and Diode laser was used as surface pretreatments of fibre posts in this study.

Diode laser Phototherapy is frequently employed in dental procedures due to their reasonable cost, their compatible size and ease of handling. [25] These lasers work at a wavelength of 805–1064 nm employing thermal energy and show excellent photo biomodulation and bactericidal properties. [25] Their clinical usage has been limited to tooth whitening, gingivectomy, frenectomy and biopsy procedures. [25] Their usage for surface pretreatment of posts is limited in literature, hence in this study diode laser as phototherapy for fiber post surface treatment was used.

A Diode laser (EZ Lase, Biolase) with a 940 nm wavelength with a 200 μ diameter tip was used in the current study. The laser was set at a power of 2 watt and was used in a pulsed mode. The posts were longitudinally divided into 4 segments and each segment was lased for 40seconds.The average power delivered was 0.18W and the energy delivered was 8J. The distance of the tip of the laser to the post was 1mm and was incident at a 90˚angle.

The pushout values achieved after diode pretreatment of fibre posts were the lowest amongst all the groups in this study. This result was in accordance with a similar study conducted by Al-Qahtani et al [25] where 2 watt Diode laser irradiation was applied on glass FPs. The values were compared with those treated with 50 μm alumina sandblasting method and was seen to be more effective than diode laser irradiation.

Siqueira et al [13] had conducted a study evaluating the surface roughness and morphology of glass fibre posts after surface treatments with Er:YAG, Er,Cr:YSGG and Diode laser. The GFP roughness and morphology was evaluated before and after surface treatment through laser confocal microscopy. It was seen that 980nm diode laser irradiation increased the surface roughness as compared to other groups; however, there was no statistically significant difference in the surface roughness before and after laser irradiation. This study also evaluated mechanical properties like flexural strength and elastic modulus of GFP after laser irradiation. It was seen that there were fused and re-solidified areas along with color changes on the diode irradiated posts suggesting excessive heating of the post. According to the author, this was because diode laser does not have a refrigeration system, so the laser energy heats the irradiated surface, melts the polymeric matrix, and fuses it to the fibers. [13] This makes diode laser an extremely aggressive surface treatment which could negatively affect the bond strength because of damage and changes to the polymeric matrix and fibres. Since the current study utilized the usage of 940nm diode irradiation in contrast to the study by Siquera et al [13], further investigation is required to evaluate the reason for low bond strength and the nature of failure between the post and core material. Research is limited in its usage as a potential surface pretreatment and requires further research with different combinations of settings.

In addition to Diode lasers, the Erbium family of lasers like Er:YAG and Er,Cr:YSGG have been used to irradiate dentin surfaces throughout literature and have shown potential. [11, 26, 27, 28] They act on tissues by thermomechanical ablation and vapourize any water present. This leads to micro-explosions that eject both inorganic and organic tissue to provide a surface with no smear layer and open dentinal tubules. [37]

In this study laser irradiation with Er,Cr:YSGG laser was also tested as a surface pretreatment although it did not result in an increase in the push out bond strength of fibre posts to composite core as compared to the control and the sandblasted fibre posts. The values were however higher than that of the Diode group as the use of water spray possibly minimized the heat generated by absorbing the excess amount of laser energy and cooled the irradiated area. Diode laser irradiation however did not make use of a refrigeration system which negatively affected the bonding potential.

A Er,Cr:YSGG laser (Biolase,Waterlase iPlus) with a 2790nm wavelength was used for the surface treatment in this study. A MZ5 Zircon, 500 μ diameter tip was used. The laser was set at a power of 1 watt with 20Hz frequency, 60% water and 40% air. The posts were lased longitudinally in a sweeping motion for 40 seconds for 2 cycles with a 10 second gap.

Kriznar et al had conducted a study [18] evaluating the micro push-out bond strength of resin material to two types of fiber posts using Er:YAG laser pretreatment. Their result showed that although there was an increase in the effective surface roughness of the post surface, there was no increase in the push out bond strength values after laser irradiation. Their study rather showed that the push out values for the laser irradiated group was much lower than the control group. It was reasoned that higher energy settings and longer pulse modes possibly caused more damage to the surface of the posts. Despite the increased surface roughness and morphological changes confirmed by SEM of Fiber post surfaces, no increase in the bond strength could be measured. The authors believed that the Micro pushout method limitations could be the reason for this result. These limitations could be that interfacial sliding friction contributes mostly to the measured fixation or retention bond strength. The authors are of the opinion that the micro push-out method could not detect the small differences in bond strengths of the core build-up material to the Fiber posts. This result was also supported by a study by Kurt et al [2] , where the lowest bond strength of composite core material to Fibre Post was observed at Er:YAG pulse energies of 500 mJ while stronger bonds were recorded with lower energy doses, which raises a potential question into the appropriate laser parameters for surface irradiation.

The result of the current study in addition to the study by Kriznar et al, is in accordance with a meta-analysis conducted by Davoudi et al [3], who inferred that there was no significant differences in push out bond strength of fibre posts between Er,Cr:YSGG laser irradiation and sandblasting technique.

Contrasting results were reported by Hashmikamangar et al [1] who compared the effects of Er,Cr:YSGG laser irradiation (with different powers of 1, 1.5 and 2 watt) and sandblasting with 50µm alumina particles on the push out bond strength of FPs bonded to Composite core. The authors reported that laser irradiation with 1W power caused significantly higher push out bond strength values than the sandblasting technique. Moreover, it was concluded that 2 watt power setting could alter the homogeneity and integrity of glass fibre posts causing dugout areas in the resin matrix. This could in turn reduce their bonding ability to composite material.

Kurtulmus et al [20] evaluated the effect of Er,Cr:YSGG on glass and quartz posts at 1 watt ,1.5 watt and 2 watt. The result of their study was similar to the study by Hashmikamangar et al [1] and showed that regardless of the fiber post composition, 1 and 1.5 watt laser applications increased the bond strength significantly in comparison with the control group. However, there was no significant difference between 2 watt and the control group for either fiber post system. Higher power (2 watt) of the laser was reasoned to cause destruction of fibers and affect the integrity of the posts, and thus decrease the ability of fibers to bond with resin core material.

Hybrid composites and Flowable composites have been reported to show good adaptation to fibre post surfaces. [2] The overall mechanical properties of flowable composites have proven to be superior to conventional composites. [2] Hence, in this current study a dual cure composite material like ParaCore (Coltene) was chosen, which had been recommended by the manufacturer as an adhesive luting agent and core built up material. [2]

Many factors like functional loading, thermocycling and penetration of oral fluids in the interfaces between the materials can have a role on the retention between the posts and composite core. [14] In the current study, thermocyling and water storage had been used to induce artificial aging in order to simulate clinical wear in the post and core restoration. Prior to push out bond testing, all the specimens were subjected to thermocycling (5000 cycles, 5°–55℃, 30 sec dwell time) and 24 hr storage in distilled water.

Thermal changes have shown to degrade the physico-chemical properties of composite there by compromising its bond to posts. [1] This is because of the difference in the thermal coefficients of the posts and composite core leading to degradation of the fibres or the matrix. [9]

Water storage has also shown to negatively affect the bond within and on the surface of composite thereby compromising its bond strength. [14] Sahafi [38] and Bitter et al [39] stated that the bond strength between post and core depends more on the post material and the surface treatment of posts than on the storage condition and duration. One of the limitations of this study was that all the specimens were subjected to thermocycling and water storage; hence there was no comparison to be made between specimens that were not aged to artificially aged ones. To evaluate the actual effect of these techniques on the post and core interface, studies with half samples thermocycled and half samples that are not thermo cycled can be conducted in the future.

In the current study, the adhesion of posts to composite core after different surface treatments was determined using a micro push out test. Micro push out bond strength is essentially a type of shear bond strength which depends on the degree and stability of interfacial micromechanical interlocking and chemical adhesion. [19] This test requires the dimensions of the specimens to be reduced in order to achieve a uniform stress distribution. [8] This method provides a comparatively more accurate estimation of bond strength compared with the conventional shear test, as fracture occurs in parallel (not transverse) with the bonding interface, which simulates the clinical conditions. [30] A further advantage of using the “thin slice” push out test is that multiple specimens can be obtained from a single bonded fiber post and composite core specimen. [30]

One of the limitations of the present study is that only one composite core resin and three surface treatments of the posts were evaluated in in-vitro conditions. Using a combination of pretreatments and different core materials can lead to different results. [9] Furthermore, the surface characteristics of the dislodged posts and fractured posts and core were not analyzed by using scanning electron microscope to understand the mode of failure.

The possibility of the values for the control group being higher than those of the laser irradiated groups could be because of the irregular and damaged matrix of the laser irradiated posts with dugout areas which may have impeded the bonding to the composite core material. [2, 18] However, there was not a substantial statistical difference between the group values which requires further investigation into the different parameters such as emission mode, pulse energy, frequency, pulse duration, and air/water spray cooling in the future. A further investigation into the limitations of the micro push out bond test and studies overcoming these are also the need of the hour.

By relying on the result of this study it can be concluded that:

Laser irradiation of FPs body does not increase the final push out bond strength of bonded FPs to Composite core material significantly in accordance with other studies [2, 18]. Nevertheless, Er,Cr:YSGG laser irradiation may be more effective than Diode laser irradiation and show potential.

- <u>Conclusion</u>

Within the limitations of this in vitro study, the following conclusions were drawn:

1) Surface treatment with 50-µm aluminum oxide lead to an increase in the push-out bond strength of glass fibre posts to composite core(24.60 ± 2.562) after subjecting the samples to thermocycling and water storage. It resulted in the highest push out values as compared to other groups.

2) 1 W Er,Cr:YSGG laser (22.43 ± 3.69) and 2 W Diode laser (20.30 ± 3.374) pretreatments showed no increase in the bond strength between the fibre posts and composite cores as compared to control and sandblasting group.

3) Despite the increase in bond strength in the sandblasting group and the control group, the increase was not of statistically significant value.

- <u>References</u>

(1) Hashemikamangar SS, Hasanitabatabaee M, Kalantari S, Gholampurdehaky M, Ranjbaromrani L, Ebrahimi H. Bond strength of fiber posts to composite core: effect of surface treatment with Er,Cr:YSGG laser and thermocycling. J Lasers Med Sci. 2018;9(1):36-42.

(2) Kurt M, Güler AU, Duran İ, Uludamar A, İnan Ö. Effects of different surface treatments on the bond strength of glass fiber-reinforced composite root canal posts to composite core material. Journal of Dental Sciences. 2012 Mar 1;7(1):20-5.

(3) Davoudi A, Mosharraf R, Akhavan A, Zarei F, Pourarz S, Iravani S. Effect of laser irradiation on push-out bond strength of dental fiber posts to composite resin core

buildups: A systematic review and meta-analysis. Photodiagnosis and Photodynamic Therapy. 2019 Sep 1;27:184-92.

(4) Arslan H, Barutcigil C, Yılmaz CB, Ceyhanlı KT, Topcuoglu HS. Push-out bond strength between composite core buildup and fiber-reinforced posts after different surface treatments. Photomedicine and laser surgery. 2013 Jul 1;31(7):328-33.

(5) Pelozo LL, Silva-Neto RD, Corona SA, Palma-Dibb RG, Souza-Gabriel AE. Dentin pretreatment with Er: YAG laser and sodium ascorbate to improve the bond strength of glass fiber post. Lasers in Medical Science. 2019 Feb;34(1):47-54.

(6) Maroulakos G, Wanserski MW, Wanserski MM, Schuler EJ, Egan CP, Thompson GA. Effect of airborne-particle abrasion on 3-dimensional surface roughness and characteristic failure load of fiber-reinforced posts. The Journal of prosthetic dentistry. 2019 Mar 1;121(3):461-9.

(7) Jayasenthil A, Solomon-Sathish E, Venkatalakshmi-Aparna P, Balagopal S. Fracture resistance of tooth restored with four glass fiber post systems of varying surface geometries-An in vitro study. Journal of Clinical and Experimental Dentistry. 2016 Feb;8(1):e44.

(8) Cekic-Nagas I, Sukuroglu E, Canay S. Does the surface treatment affect the bond strength of various fibre-post systems to resin-core materials?. Journal of dentistry. 2011 Feb 1;39(2):171-9.

(9) Mosharraf R, Baghaei Yazdi N. Comparative evaluation of effects of different surface treatment methods on bond strength between fiber post and composite core. The journal of advanced prosthodontics. 2012 May 1;4(2):103-8.

(10) Alshahrani A, Albaqami M, Naji Z, Al-Khunein Y, Alsubaie K, Alqahtani A, Al-Thobity A. Impact of different surface treatment methods on bond strength between fiber post and composite core material. The Saudi Dental Journal. 2020 Mar 19.

(11) Gomes KG, Faria NS, Neto WR, Colucci V, Gomes EA. Influence of laser irradiation on the push-out bond strength between a glass fiber post and root dentin. The Journal of prosthetic dentistry. 2018 Jan 1;119(1):97-102.

(12) Ghavami-Lahiji M, Benedicenti S, Karimian R, Shahabi S. Influence of Er, Cr: YSGG Laser Surface Treatments on Micro Push-Out Bond Strength of Fiber Posts to Composite Resin Core Materials. Journal of Dental Biomaterials. 2018 Mar 5;5(1):533-42.

(13) Barbosa Siqueira C, Spadini de Faria N, Raucci-Neto W, Colucci V, Alves Gomes E. Evaluation of mechanical properties of glass fiber posts subjected to laser surface treatments. Photomedicine and Laser Surgery. 2016 Oct 1;34(10):460-6.

(14) Khamverdi Z, Abbasi S, Habibi E, Kasraei S, Azarsina M, Ebadi S. Effect of storage time on microtensile bond strength between quartz fiber post and composite core after different post surface treatments. Journal of conservative dentistry: JCD. 2011 Oct;14(4):361.

(15) Akgungor G, Sen D, Aydin M. Influence of different surface treatments on the short-term bond strength and durability between a zirconia post and a composite resin core material. The Journal of prosthetic dentistry. 2008 May;99(5):388.

(16) Choi Y, Pae A, Park EJ, Wright RF. The effect of surface treatment of fiber-reinforced posts on adhesion of a resin-based luting agent. The Journal of prosthetic dentistry. 2010 Jun 1;103(6):362-8.

(17) Albashaireh ZS, Ghazal M, Kern M. Effects of endodontic post surface treatment, dentin conditioning, and artificial aging on the retention of glass fiber-reinforced composite resin posts. The Journal of prosthetic dentistry. 2010 Jan 1;103(1):31-9.

(18) Križnar I, Jevnikar P, Fidler A. Effect of Er: YAG laser pretreatment on bond strength of a composite core build-up material to fiber posts. Lasers in medical science. 2015 Feb 1;30(2):733-40.

(19) Liu C, Liu H, Qian YT, Zhu S, Zhao SQ. The influence of four dual-cure resin cements and surface treatment selection to bond strength of fiber post. International journal of oral science. 2014 Mar;6(1):56-60.

(20) Kurtulmus-Yilmaz S, Cengiz E, Ozan O, Ramoglu S, Yilmaz HG. The effect of Er, Cr: YSGG laser application on the micropush-out bond strength of fiber posts to resin core material. Photomedicine and laser surgery. 2014 Oct 1;32(10):574-81.

(21) Sipahi C, Piskin B, Akin GE, Bektas OO, Akin H. Adhesion between glass fiber posts and resin cement: evaluation of bond strength after various pre-treatments. Acta Odontologica Scandinavica. 2014 Oct 1;72(7):509-15.

(22) Barutcigil Ç, Barutcigil K, Yasa B, Arslan H, Akcay M. Build-Up of a Resin Composite Core in a Fiber-Reinforced Post by a 2.78 μm-Pulsed Laser Treatment. Journal of Laser Micro/Nanoengineering. 2015 May 1;10(2).

(23) Arslan H, Ayrancı LB, Kurklu D, Topçuoğlu HS, Barutcigil C. Influence of different surface treatments on push-out bond strengths of fiber-reinforced posts luted with dual-cure resin cement. Nigerian journal of clinical practice. 2016;19(2):218-22.

(24) Pimentel AL, de Brito Granja R, Tschelakow VP, Novis RM, Léon BL. SURFACE TREATMENT TYPE AND UNION RESISTANCE BETWEEN FIBERGLASS POSTS

AND COMPOSITE RESIN. Journal of Dentistry & Public Health. 2017 Dec 18;8(4):106-16.

(25) Al-Qahtani AS, AlZain SA, AlHamdan EM, Tulbah HI, Al Alsheikh HM, Naseem M, Vohra F. A comparative evaluation of the effect of phototherapy of fiber post on its bond strength to dental composite. Photodiagnosis and photodynamic therapy. 2018 Dec 1;24:228-31.

(26) Rezaei-Soufi L, Tapak L, Forouzande M, Fekrazad R. Effects of motion direction and power of Er, Cr: YSGG laser on pull-out bond strength of fiber post to root dentin in endodontically-treated single-canal premolar teeth. Biomaterials Research. 2019 Dec;23(1):1-8.

(27) Achammada S, Thayyil S, Joy J, Divakar N, Sathe S, Sathyanathan S. Impact of different laser treatments on push-out strength of post luted with resin cement: An in vitro study. International Journal of Oral Care and Research. 2018 Oct 1;6(4):49.

(28) Araújo DS, do Nascimento VP, Monte TL, Falcão CA, Rego MR. EVALUATION OF THE EFFECTS OF SURFACE TREATMENT ON THE ADHESION OF FIBERGLASS PINS: A SYSTEMATIC REVIEW. Focus Oral Research. 2020 Mar 4;2(3):98-112.

(29) Nayak M, Shenoy V. Endodontic retreatment and rehabilitation of a mutilated mandibular molar using laser surface treated glass fiber post: A case report.

(30) Elsaka SE. Influence of chemical surface treatments on adhesion of fiber posts to composite resin core materials. Dental materials. 2013 May 1;29(5):550-8.

(31) Aksornmuang J, Foxton RM, Nakajima M, Tagami J. Microtensile bond strength of a dual-cure resin core material to glass and quartz fibre posts. Journal of Dentistry. 2004 Aug 1;32(6):443-50.

(32) Balbosh A, Kern M. Effect of surface treatment on retention of glass-fiber endodontic posts. The Journal of prosthetic dentistry. 2006 Mar 1;95(3):218-23.

(33) Soares CJ, Santana FR, Pereira JC, Araujo TS, Menezes MS. Influence of airborne-particle abrasion on mechanical properties and bond strength of carbon/epoxy and glass/bis-GMA fiber-reinforced resin posts. The Journal of prosthetic dentistry. 2008 Jun 1;99(6):444-54.

(34) Monticelli F, Osorio R, Sadek FT, Radovic I, Toledano M, Ferrari M. Surface treatments for improving bond strength to prefabricated fiber posts: a literature review. Operative Dentistry. 2008 May;33(3):346-55.

(35) D'Arcangelo C, Cinelli M, De Angelis F, D'Amario M. The effect of resin cement film thickness on the pullout strength of a fiber-reinforced post system. The Journal of prosthetic dentistry. 2007 Sep 1;98(3):193-8.

(36) Elnaghy AM, Elsaka SE. Effect of surface treatments on the flexural properties and adhesion of glass fiber-reinforced composite post to self-adhesive luting agent and radicular dentin. Odontology. 2016 Jan 1;104(1):60-7.

(37) Kirmali O, Kustarci A, Kapdan A, Er K. Effects of dentin surface treatments including Er, Cr: YSGG laser irradiation with different intensities on the push-out bond strength of the glass fiber posts to root dentin. Acta Odontologica Scandinavica. 2015 Jul 4;73(5):380-6.

(38) Sahafi A, Peutzfeldt A. Durability of the bond between resin composite cores and prefabricated posts. Acta Odontologica Scandinavica. 2009 Jan 1;67(5):271-6.

(39) Bitter K, Noetzel J, Neumann K, Kielbassa AM. Effect of silanization on bond strengths of fiber posts to various resin cements. Quintessence International. 2007 Feb 1;38(2).

- Tables:

GROUPS	SURFACE TREATMENT	Minimum	Maximum	Mean	S.D	F value	P value
A	CONTROL	18.81	29.36	23.92	4.695	1.35	0.29
B	Er,Cr:YSGG LASER	18.50	26.57	22.43	3.69		
C	DIODE LASER	16.90	24.75	20.30	3.374		
D	SANDBLASTING	20.95	27.23	24.60	2.562		

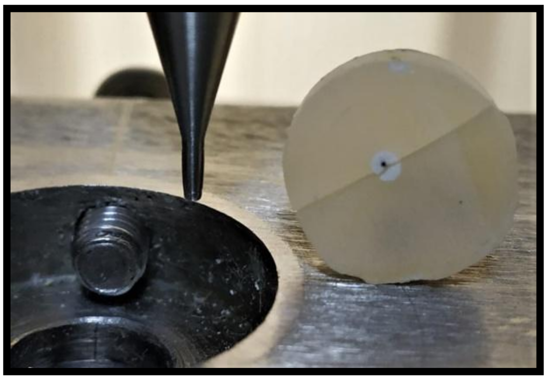
Table 1: comparison of the mean push bond strength among the groups using anova

Groups		Mean Difference	p value
CONTROL	DIODE LASER	1.488	1.000
	Er,Cr:YSGG LASER	3.622	.825
	SANDBLASTING	-0.678	1.000
DIODE LASER	Er,Cr:YSGG LASER	2.134	1.000
	SANDBLASTING	-2.166	1.000
Er,Cr:YSGG LASER	SANDBLASTING	-4.300	.492

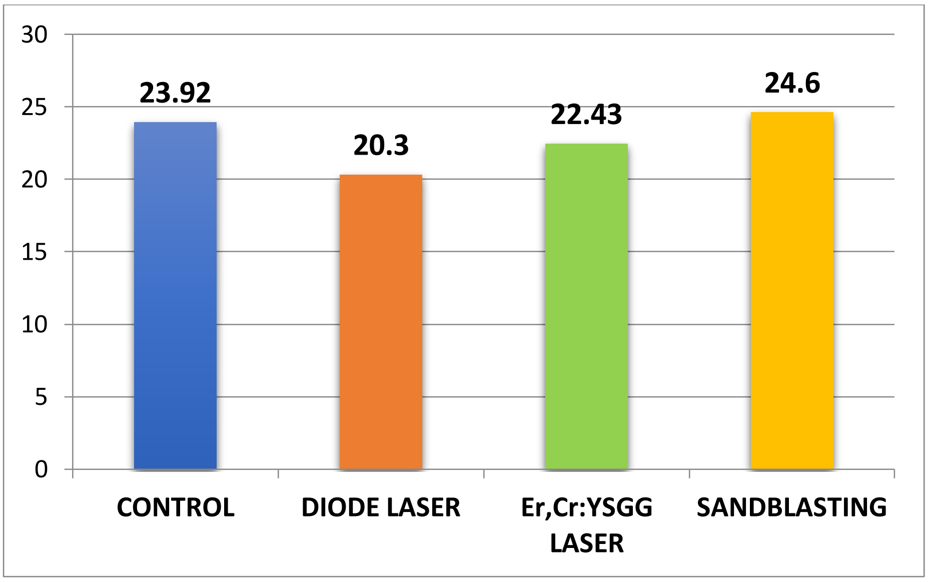
Table 2: post hoc bonferroni

- <u>Figures:</u>

- I



- II



- III

- Legends for illustrations:
- I- Specimens mounted on a Universal testing machine
- II- Failure through the specimen
- III- Comparison of the mean push bond strength among the groups