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Effect of Er,Cr:YSSG laser on dental Veneers removal submitted to gamma radiation

Nathalia Zanini[1], Thais Freitas Rabelo[1], Claudia Bianchi Zamataro[1], Amanda Caramel Juvino[1], Nielsen Grosko Kuchar[1], Pedro Arthur Augusto de Castro[1], Patrícia Aparecida da Ana[2], Denise Maria Zezell[1]

[1]Instituto de Pesquisas Energéticas e Nucleares (IPEN - CNEN \ SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
zezell@usp.br

[2] Universidade Federal do ABC(UFABC)
Centro de Engenharia, Modelagem e Ciências Sociais Aplicadas (CECS)
Universidade Federal do ABC
Rua Arcturos, 03 - Jardim Antares
Bloco Delta, Sala 312
CEP 09606-070 –
São Bernardo do Campo – SP

ABSTRACT

The search for aesthetical rehabilitive treatment such as porcelain veneers is increasing over the past years. After CEP-FOUSP approval, the present study investigated the debonding of 20 ceramic fragments of lithium disilicate(5x5x1 mm) from human dental enamel bond with Variolink ® N. The samples were splitted in two groups: control (without gamma irradiation) and treatment (gamma irradiation: GL). EDS and FTIR was performed on enamel in both groups, before and after treatment. After cementation of the ceramic fragments the control group was only irradiated with Er, Cr: YSGG laser (λ = 2.78 nm) to remove the fragments, whereas the GL was gamma irradiated with 0.07 kGy followed by laser irradiation Er, Cr: YSGG for removal of laminates.The laser parameters were previously determined as follows: 3.5 W. The gamma and laser (GL) group was exposed to gamma radiation and the erbium laser was applied in both groups to remove lithium disilicate laminates from human dental enamel. Thus, the load required to remove the laminates after simulation of the radiotherapy treatment in the human dental enamel was analyzed by mechanical assay. In this assay, the GL group presented higher loads for the removal of the laminates compared to the control group. This indicates that the gamma radiation induces a water radiolysis by modifying the hybrid layer of the adhesive cement and increases the bond between the enamel and the resin cement, which hinders the laser debonding of the laminates.

1. INTRODUCTION

After the comprehension of the importance of functional rehabilitation, Modern Dentistry is characterized by the 'standardization' of smiles throughaesthetics procedures. Porcelain veneers and dental contact lenses are increasingly frequent and indicate an incessant search for aesthetic perfection of the smile (1). Ceramic laminates have become the most sought after by patients because they are minimally invasive (2). Many new advancesare made to aesthetic dental procedures related to the manufacture, cementation, maintenance and removal of ceramic laminates(3) Laser removal of ceramic laminates has become more frequent as aesthetic procedures need to be replaced and such removal is traditionally performed by diamond drills with rotatory instruments (1) (3). The lasers have been preconized as an alternative for the removal of the laminates (4) (3)(5), but the dental surgeon should take into account the impact that this type of cosmetic procedure may have in the future. Extremely young patients who are exposed to aesthetics procedures may face other non-related health problems throughout life such as cancer. Radiotherapy of head and neck cancer can cause many comorbidities in the oral environment that might damage the adhesiveness of the laminates(6)(7)(8).Thus, the present work aims to evaluate *in vitro* the human dental enamel, lithium disilicate fragments and resin cements after gamma irradiation simulating radiotherapy for the treatment of head and neck cancer.

2. MATERIALS AND METHODS

2.1 - Preparation of human enamel samples

After approval by the Ethics Committee from the Faculty of Dentistry from the University of São Paulo (CAAE 02717618.8.0000.0075; 97050218.6.0000.0075) human teeth were immersed in Thymol solution for 48 h(9)in order to avoid the crossed contamination of the operator and kept under refrigeration.After the disinfection, with a rotatory dental piece (Gnatus, PR, Brazil), a multilaminated rotary instrument (KG Sorensen, SP, Brazil) and distilled water spray from the equipment reservoir, the teeth were segmented. It was used 20 samples of human dental enamel. In order to maintain a sample pattern and a better utilization of the biological tissue, acrylic resin (VipiCril Plus, Brazil) was used to inlay the hard tissue using the embossing press (Arotec, Model PRE-30Mi, Brazil). After the enamel samples were embedded in acrylic resin, they were polished plane, with a sequence of water sandpaper 100, P400, P600, P1200, P2500 and P4000.(10) Each sandpaper was used, approximately, for 5 minutes then samples were immersed in an UltraMet 2 Sonic Cleaning solution (Buehler®, Lake Blulf, USA) and taken to the dental ultrasonic bath (Cristófoli, Campo Mourão, Paraná, Brazil) for 3 minutes. The ultrasonic bath removed any abrasive grain present in the specimen and the final polishing was performed with felt disc and a suspension with 1μm diamond granules (MetaDi ™Monocrystalline Diamond Suspension, Buehler®, Lake Blulf, USA). Following the tooth preparation, we performed the surface microhardness (SMH) (11)and Fourier Transform Infrared Spectroscopy(FTIR) analysis.

2.2 - Preparation of lithium disilicate fragments

The lithium disilicate fragments were manufactured at an external prosthetics laboratory (Flores Specialized Prosthetics, São Paulo, Brazil. Technician Cristina Flores) with the E-max technology.Fragments were standardized with dimensions of 5x5x1mm.

2.3 - Cementing procedure, gamma irradiation and laser debonding parameters

The cementation was performed with Variolink® N resin cement, following the manufacturer's instructions. The 20 final samples composed of human dental enamel + cement + 'laminates' were divided into two groups: controlgroup, and Gamma + Laser (GL)group. The control group were irradiated with the Er,Cr:YSGG laser (Biolase, San Clemente, USA). in the 3.5 W, 20 Hz, 60% water and 40% air flow protocol. The GL group was submitted to gamma radiation of 0.07kGyat a Co^{60}multipurpose irradiator(9), and then the Er,Cr:YSGG laser in the 3.5 W, 20 Hz, 60% water and 40% air flow protocol. In order to standardize laser irradiation, a stepper motor with 5mm displacements in the X-axis and 5mm in the Y-axis was used(3). In both groups, the laser irradiation was performed with a sapphire type (MGG6-4mm) with a diameter of 0.6 mm (Biolase, San Clemente, USA) with a focal length of 1 mm, as shown at Figure 1.

Figure 1: Laser tip MGG6-4mm(Biolase, San Clemente, USA)used with focal length of 1mm.

2.4 - Surface Microhardness

The baseline surface microhardness was performed in order to homogenize the initial mineral content of the biological samples and make the results of the next steps more reliable. The homogeneous universe of biological samples and subsequent randomization avoid final bias at the results. It was performed the Knoop Hardness test where twelve endentantions were made from a selected marked board of the sample. Thus, in this Knoop hardness analysis was used a constant load of 50 gf, compatible with the resilience of the sample (about 320 kg / mm^2 for dental enamel) applied perpendicularly onto the surface of the sample for 5 seconds through a microdurometer (Shimadzu HMV-2000, Japan) provided with pyramidal diamond.(11)

2.5 - Energy Dispersive X-Ray Spectroscopy

The energy dispersive x-ray spectroscopy is an elemental sample analysis of the contents. The analyzed elements were selected because they are present in the hydroxyapatite composition or at the resin cement composition.

2.6 - Fourier-Transform Infrared Spectroscopy

The Fourier transform infrared spectroscopy (ATR-FTIR) is defined as spectroscopy, which is the set of characterization techniques that obtain information from the sample due to the interaction of the electromagnetic radiation.

The spectrophotometer used (Thermo-Nicollet, USA) emits several wavelengths that are absorbed by the medium and the non-absorbed ones are transmitted and detected by the detector, generating a peak. Several peaks (bands) generate a spectrum. It was analyzed whether the gamma radiation generates the disappearance of bands in the dental enamel structure, for example, the disappearance of the water band due to the dehydration caused by gamma or Er, Cr:YSGG laser irradiation. These possible differences in band intensities show changes in the molecular structure of hydroxyapatite. Eventually, the FTIR technique does not have sufficient sensitivity to generate difference in spectra obtained before and after irradiation. To do so, a statistical treatment is proposed by means of a standard analysis between the phosphate / amide ratio to verify the significant differences in the spectra obtained before and after irradiation, according to the propositions in the literature.

2.7 - Mechanical Test

After the irradiation, the samples were submitted to a traction test in order to evaluate if force is still needed to move the lithium disilicate fragments after debonding with Er,Cr:YSSG laser. Themechanical test was performed using a universal test machine (Instron, MA, USA). A prefabricated base for this purpose was adapted to hold the samples in position. The active tip in "knife" shape was attached to the horizontal crossbar of the Instron® machine. The base with the specimen was placed in the lower part, on the specific support of the machine. The sample was affixed with the label facing downwards and this sample edge should be parallel with the horizontal plane to avoid concentrating stress somewhere that may cause loss of the parallelism (Figure 2).

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Figure 2: Sample composed by human dental enamel, resin cement and lithium disilicate laminate submitted to mechanical test in a Instron® Machine

3. RESULTS

3.1 - Surface Microhardness

Baseline surface microhardness (Figure 3) allowed to select two homogeneous groups, after the normalization of the average enamel microhardness (KHN ~ 300) and the exclusion of the outliers, avoiding bias at the results. The human dental enamel samples were randomized previously to the SMH analysis and again, between groups, after the normalization of the sample universe.

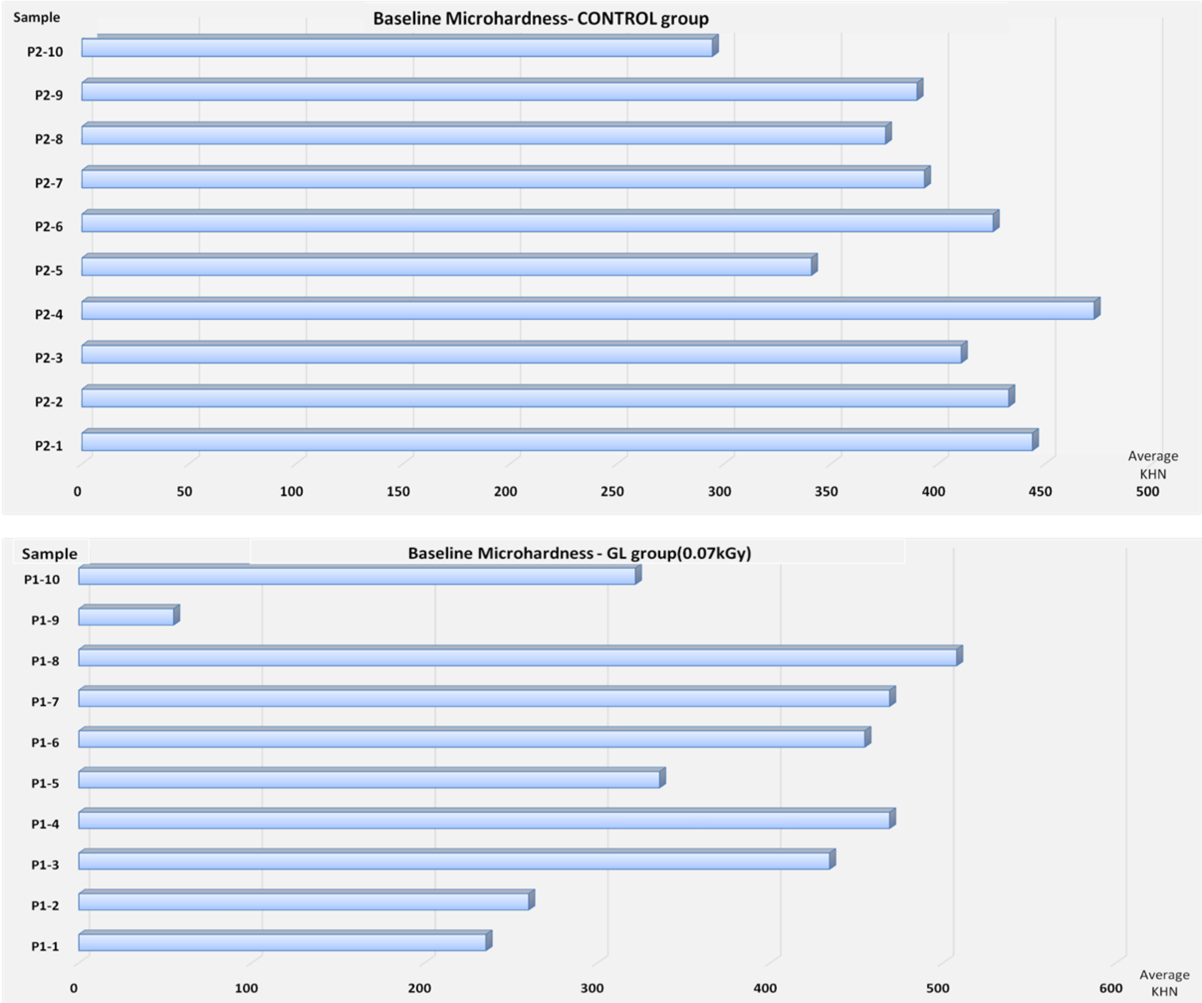

Figure 3: Baseline surface microhardness in both groups.

3.2 - Energy Dispersive X-Ray Spectroscopy

The EDS analysis, before and after the debonding in both groups, provided the percentage per mass of each previously selected element. Regarding the composition of the hydroxyapatite, it was notobserved significant difference at the intra group analysis when the initial condition was compared to after Er,Cr:YSGG laser irradiation. Both groups, after the debonding with Er,Cr:YSGG laser showfluorine and carbon percentage increased since these elements were in Variolink®N composition (Figures5 and 6)

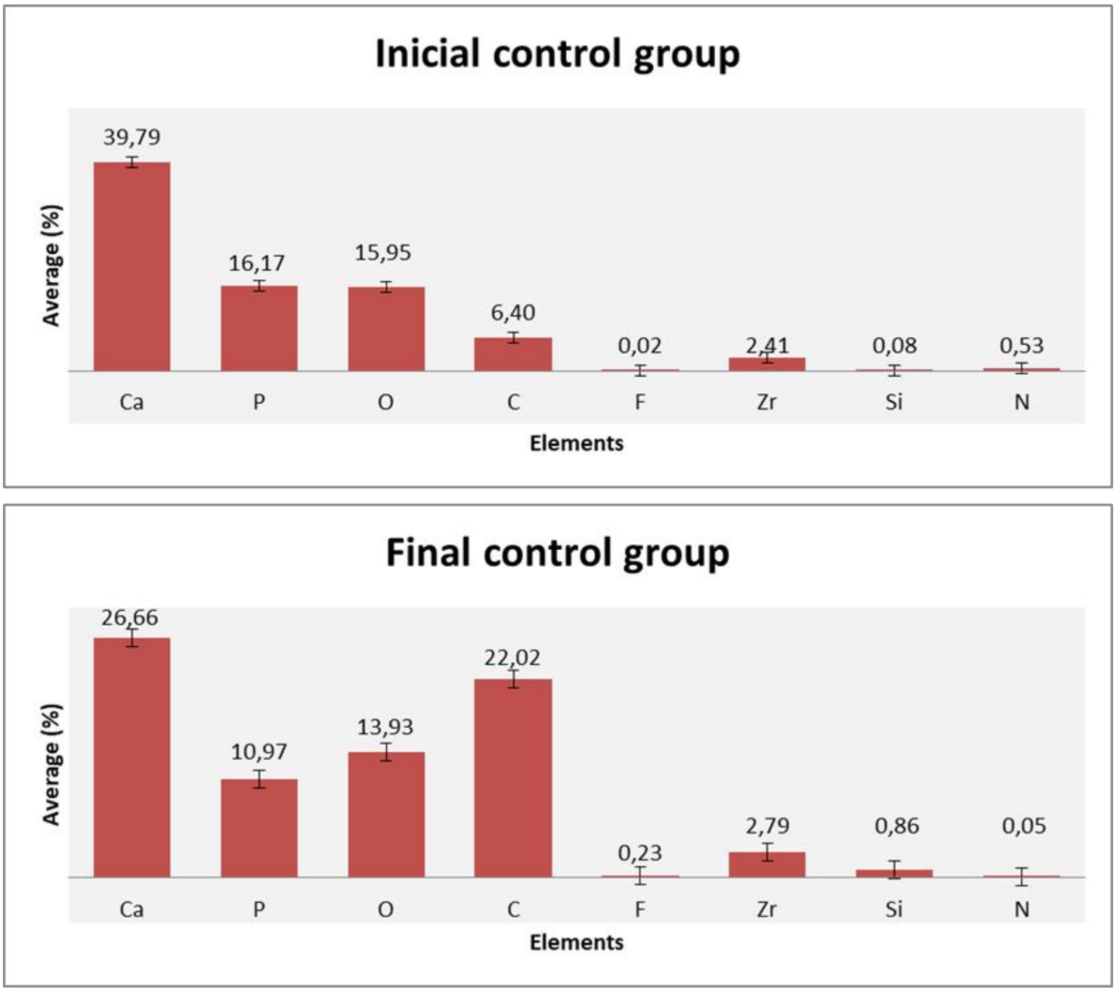

Figure 4: EDS in control group before and after the debonding with Er,Cr:YSGG laser

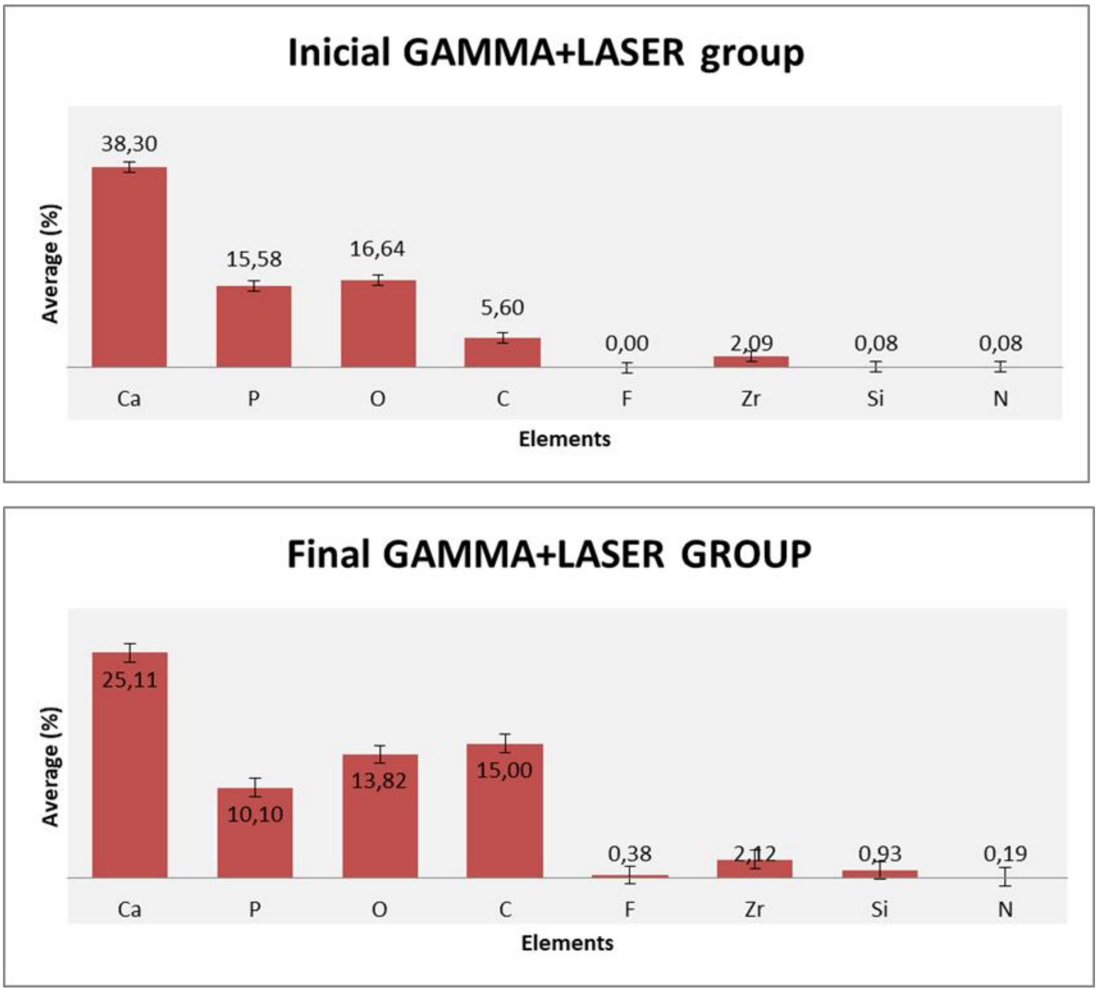

Figure 5:EDS in GL groupbefore and after the gamma radiation and debonding with Er,Cr:YSGG laser

3.3 - Fourier-Transform Infrared Spectroscopy

The FTIR analysis after the association to ionizing (gamma) and non-ionizing (Er,Cr:YSGG laser)radiation in a GLgroup indicated an increase in organic composition of enamel due to water radiolysis (Figure 6). FTIR shows the baseline mean spectra in gamma group and no gamma group.Contrary to the control group which had a decrease in an inorganic composition, due to laser ablation. It was verified no formation of new compounds. In a baseline gamma, group the median and mean were coincident and in a baseline no gamma group it was not observed this coincidence.

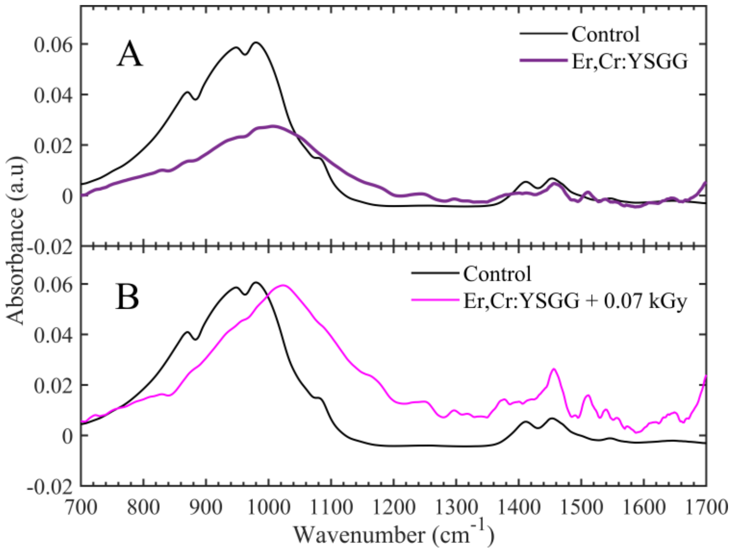

Figure 6A- Black solid line is the average of the spectra of the control group and purple solid line is the average of the spectra of the Er,Cr:YSGG group. B- Black solid line is the average of the spectra of the control group and pink solid line is the average of the spectra of the Er,Cr:YSGG group.

3.4 - Mechanical Test

Themechanical test was performed using a universal test machine that showed gamma radiation promoted an increase in bonding of laminates due to water radiolysis, because the debonding load in GL group expressed loads until 40kgf and in a control group the highest load was 30kgf.This indicates that the gamma radiation increases the union between the enamel and resin cement and makes the replacement of laminates more difficult.

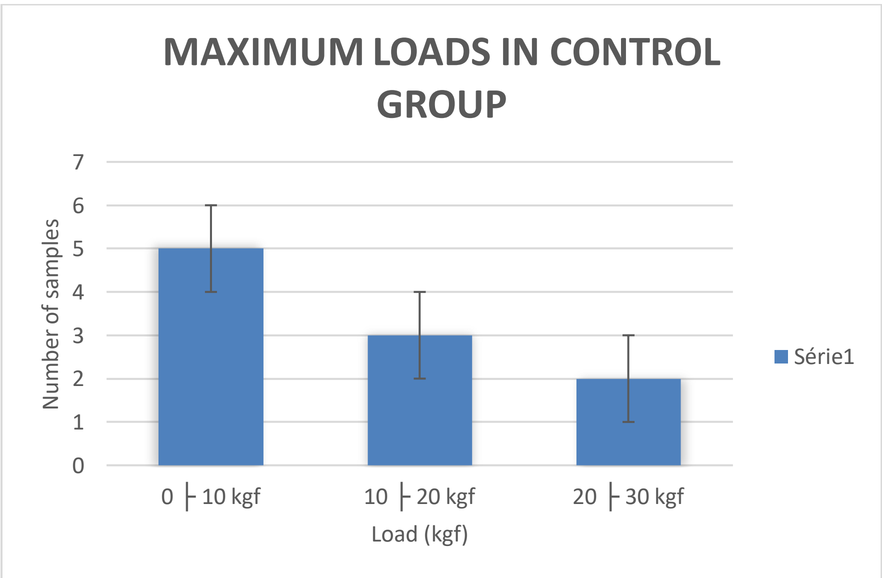

Figure 7: Graph of mechanical test in Instron® Machine in control group

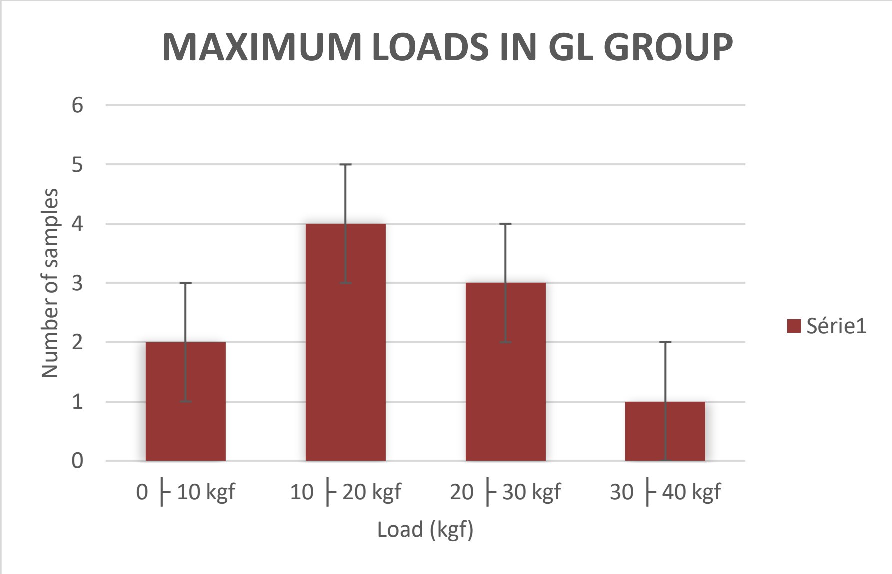

Figure 8: Graph of mechanical test in Instron® Machine in GL group

4. DISCUSSION

The baseline surface microhardness(SMH) was made to homogenize the samples and create ainclusion criteria and exclusion of the outliers from initial enamel samples. According to the average dataof eleven indentations on each sample the mean intragroup and the standard deviation were calculated. The samples with outlier mean were excluded from the universe of samples. Thus, the SMH and randomization increased the reliability of the obtained data. In EDS analysis, the chemical elements fromthe human dental hydroxyapatite and from the resin cement used in laminate bonding were selected for analysis. The results of EDS after Er,Cr:YSGG in both groups showed alteration in the chemical composition of enamel since there was an increase in fluorine and carbon.This is because they are components of the resin cement used to bondlaminates to human enamel.Previously to the lithium disilicate veneers cementation, the human dental enamel suffered an acid etch in order to create tags where the liquid monomer from the adhesive system penetrates forming a mechanical bracing. This configures a so-called hybrid layer. Although the EDS analysis may not have the sensibility to differentiate the inter group analysis, such as X-Ray diffraction, the variation of organic content and fluoride was used to characterize the hybrid layer. As the SMH analysis is used as an indirect indicative of the mineral content of the enamel, the variation showed at the EDS corroborates the formation of ahybrid layer of hydroxyapatite and adhesive system containing fluoride. After gamma radiation and Er, Cr:YSGG laser debonding of the laminates, this hybrid layer seems to remain at the within of the enamel which can be inferred as a positive result in terms of enamel maintenance. Comparing to the traditional method to remove laminates, which is the rotatory instrument, the maintenance of the enamel surface seems to be an notable advantage of the Er, Cr:YSGG laser use. Once the rotatory instrument relies on the dexterity of the operator, the laser debonding of laminates not also seems to be faster as secure and minimizes the risk of enamel loss.

FTIR demonstrate shifts around the phosphate band which may suggest crystallinity alterations in the enamel content.Both groups were normalized by the phosphate band. Previous studies shows no significant differences at the mineral content in terms of molecular composition with no formation or loss of compounds. But it must be taken in account that both gamma radiation and Er,Cr:YSGG laser causes interstitial water loss within the molecular structure of the hydroxyapatite. The 0.07 kGy of gamma radiation causes water radiolysis changing the fase of the hydroxyapatite crystal and diminishes the inter-crystalline spaces. The Er,Cr:YSGG laser wavelength is high absorbed by hydroxyapatite and water. The fluence used caused the water ablation. This two phenomena seems to cause a higher mechanical embracing of the hybrid layer once the gamma and laser group showed a higher shear load. Thus, the mechanical test showed a higher load required todetach laminatesin a GL group than the control group and it suggest an increase in mechanical union between human dental enamel and laminate veneer in the hybrid layer. So, according to this results, the gamma radiation and Er,Cr:YSGG laser irradiation could hinder laminates replacements due to alteration in a composition of hydroxyapatite.

5. CONCLUSIONS

The laminates removal with Er,Cr:YSGG laser is an effective alternative, even when subjected to gamma radiation, given the protocol for this procedure is used.

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