EFFECT OF RADIOTHERAPY ON THE RADIOPACITY AND FLEXURAL STRENGTH OF A COMPOSITE RESIN

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ABSTRACT

The aim of this study was to evaluate the effect of radiotherapy on the radiopacity and flexural strength of composite resin. Forty Z250 composite resin specimens were polymerized using a halogen light-curing unit and divided into 5 groups, in accordance with the radiotherapy dose: G1- without irradiation, G2- 30 Gy, G3- 40 Gy, G4- 50 Gy and G5- 60 Gy. Digital images were obtained using a GE 100 X-ray. Radiopacity values were obtained with the Digora digital imaging system and the flexural strength was evaluated with an EMIC universal testing machine. Data were submitted to ANOVA and Tukey's test. G1 presented the highest radiopacity value, followed by G3, G5, G4 and G2. For flexural strength, G1 presented the lowest value, followed by G2, G5, G3 and G4. Differences were no significant (p> 0.05). The commonly used dosage of radiotherapy treatment, did not cause alteration in the radiopacity and flexural strength of resin-based composites.

Key words: composite resins, flexural strength, radiopacity, radiotherapy.

EFEITO DA RADIOTERAPIA NA RESISTÊNCIA À FLEXÃO E RADIOPACIDADE DE RESINA COMPOSTA RESTAURADORA

RESUMO

O propósito deste trabalho foi avaliar o efeito da radioterapia na radiopacidade e resistência a flexão de uma resina composta. Quarenta corpos-de-prova da resina Z250 (3M Espe) foram confeccionados em matriz metálica com 25 x 2 x 2 mm, sendo fotoativadas com aparelho Ultralux (Dabi Atlante). Os mesmos foram divididos em 5 grupos com 8 amostras, de acordo com a dose de radiação: 1- grupo controle, não recebeu radiação; 2- radiação com 3000 rads; 3- 4000 rads; 4- 5000 rads; 5- 6000 rads. Após à radiação, foram obtidas imagens digitais diretas das amostras com o sistema Digora (Soredex), utilizando aparelho de raios-X GE100 (General Eletric), operando com 50Kvp, 10 mA, 12 impulsos. A distância foco-filme foi de 30 cm, com incidência do foco de radiação perpendicular ao plano do filme objeto. Os valores de radiopacidade foram obtidos com o software do sistema digital, utilizando escala de alumínio como referencial densitométrico. A resistência à flexão foi avaliada em máquina de ensaio EMIC (modelo DL3000) à velocidade de 1mm/min. Os dados obtidos foram submetidos à análise de variância e teste de Tukey (5%). Quanto a radiopacidade, o grupo 1 apresentou maior média (5,96 mmAl), seguido pelos grupos 3 (5,83 mmAl), 5 (5,80 mmAl), 4 (5,78 mmAl) e 2 (5,73 mmAl). Já à resistência à flexão, o grupo 1 apresentou menor média (120,25 MPa), seguido pelos grupos 2 (126,86 MPa), 5 (132,66 MPa), 3 (137,28 MPa) e 4 (143,69 MPa). Os resultados não tiveram diferença estatística entre si (p> 0,05) em virtude das doses radioterápicas utilizadas.

Palavras chave: resina composta, resistência à flexão, radiopacidade, radioterapia

INTRODUCTION

Resin-based composites have evolved greatly over recent years and are considered the material of choice for direct aesthetic restorations. Restorative materials should be radiopaque to enable the detection of secondary caries, overhangs, voids, evaluation of margins and contours, or other defects[1-5] Radiopacity is provided by glass and ceramic filler particles containing heavy metals such as barium, strontium and zirconium[3,6-7]. The current composite compositions, besides presenting adequate radiopacity to differentiate it from dental structures on a radiograph, demonstrate adequate physical and mechanical properties, such as reduced polymerization contraction and improved flexural strength and wear resistance[8]. The radiographic contrast and the definition of radiopacity are products of the selective X-ray absorption in the different structures that it goes through. Among the factors that regulate radiographic exposure, the kilovoltage has the greatest effect on the contrast of the radiographic image, when all other factors remain constant[9].

Dental structures and restorative materials present restorations are frequently vulnerable to the chemical and thermal variations that occur in the oral environment and, less frequently, to gamma radiation, such as that generated during radiotherapy used for cancer treatment. Among therapeutic schemes, radiotherapy represents a well-established resource for the treatment of head and neck cancer. Harmful secondary effects of radiotherapy has been studied since 1930[10-11], however, reports that analyze dental materials after their irradiation are scarce. The study of the effect of radiotherapy treatment on the properties of the composite resin could contribute to improve planning of the restorative clinical procedures to be executed in patients undergoing this treatment.

The aim of this study was to evaluate the effect of radiotherapy on the radiopacity and flexural strength of a photo-polymerized restorative composite resin.

MATERIALS AND METHODS

In the present study, Filtek Z250 composite resin was studied (3M ESPE, St. Paul, MN, USA). Forty rectangular specimens (25 x 2 x 2 mm) were prepared. The manufacture of the samples was carried out by inserting the composite resin in a metallic matrix until full, before covering with an acetate strip and glass blade. To compress the material and prevent bubble formation, the glass blade was gently pressed to remove excess material. The composite was polymerized in just one layer with a conventional halogen UltraLux light-curing unit (Dabi Atlante, Ribeirão Preto, SP, Brazil) for 20 sec., with an intensity of 570 mW/cm². The specimens were exposed as whole on the 25mm length. Specimens were stored at 37ºC, 100% relative humidity, for 24 hours to assure complete polymerization.

After this procedure, the specimens were divided into five groups with eight samples each in accordance with the radiotherapy dose to be used used: G1- without irradiation (control), G2- 30 Gy, G3- 40 Gy, G4- 50 Gy and G5- 60 Gy. The irradiation doses were selected in accordance with the most common recommendations for tumor treatments in the dental area. Usually dose about 30 Gy are used for lymphoma treatments and, 50-60 Gy for carcinomas.

A Alcyon II cobalt therapy device was used. (General Electric, Buc, France) with emission of gamma rays from a cobalt-60 (COT-20) source.

The specimens as a whole were irradiated in a single session, with a varied exposure time, according to the dose. For 30 Gy, the time used was 30 minutes; for 40 Gy, 40 minutes; for 50 Gy, 50 minutes; and for 60 Gy, 60 minutes.

Radiographic density

For the radiographic analysis of the composite specimens, digital images were obtained using the GE 100 X-ray device (General Electric, Milwaukee, WI, USA), operating at 50 kVp, 10 mA and 12 pulses. The focus-film distance was 30 cm and the irradiation beam incidence was perpendicular to the plane of the sensor-samples.

As a densitometric reference, a 9-step aluminum stepwedge (alloy 6063, ABNT) was used in the digital radiographic images and radiographed concomitantly with specimens, allowing the verification of the resin-based materials' radiopacity in accordance with the specifications of the International Standard Organization (ISO/DP 4049). The digital radiographic image was obtained with a storage phosphor plate (Digora, Soredex Orion Corporation, Helsinki, Finland). Two or 3 specimens from each group were placed on each phosphor plate with the aluminum stepwedge and the metal code number. The phosphor plates were scanned in a Digora scanner, and the images evaluated by Digora Software for Windows 1.51, using densitometric analysis. This software automatically calculated the mean grey shade values in the selected areas in each of the items of the radiopacity analyzed (specimens and aluminum stepwedge), which were used for the calculations required.

Five density readings were obtained from the items (specimens and stepwedge) on each image, and the arithmetic mean of these repetitions was calculated and considered the radiographic density of the item. The radiographic density value of each specimen was expressed as equivalent aluminum thickness (in millimeters – mm Al), from an equation obtained on the dispersion graph of density values at each aluminum step, versus its corresponding aluminum thickness. The equation from the curve was obtained from the 3 values of the graph (linear regression): the radiopacity value of the step of the aluminum stepwedge closest to the specimen radiopacity was calculated from the value of the step above and the step below. A dispersion graph was obtained for each digital image.

Flexural strength

Flexural strength measurements were performed on an EMIC DL-3000 Universal Testing Machine (EMIC Equipments and Test Systems Ltda, São José dos Pinhais, PR, Brazil), at the speed of 1mm/min. The flexural strength was calculated according to equation 1.

$$\sigma = \frac{3Fl}{2bh^2} \quad (1)$$

where σ is the flexural strength, *F* the maximum force (N), *l* the distance between the supports (mm), *b* the sample length (mm) and *h* the sample thickness (mm).

Statistical analysis

The radiopacity and flexural strength data were submitted to one-way analysis of variance (ANOVA) and Tukey´s test (α=0.05).

RESULTS

The density values of the groups investigated were expressed as equivalents of aluminum thickness. Density and flexural strength values are presented in Table 1. The control group showed the highest radiopacity value, followed by the groups irradiated with 40 Gy, 60 Gy, 50 Gy and 30 Gy, without any statistical differences between these values (p=0.3752). Control group showed the lowest flexural strength value, followed by the groups irradiated with 30 Gy, 60 Gy, 40 Gy and 50 Gy, respectively, without any statistical differences between these values (p=0.1301).

Table 1: Density and flexural strength values of control/irradiated groups. Density values are expressed as equivalent aluminum thickness.

Group	Radiopacity (mmAl)	Flexural Strength (MPa)
Control	5.96 (0.22)^a	120.25 (21.58)^b
30 Gy	5.73 (0.27)^a	126.86 (19.73)^b
40 Gy	5.83 (0.27)^a	137.28 (19.32)^b
50 Gy	5.78 (0.18)^a	143.69 (29.44)^b
60 Gy	5.80 (0.14)^a	132.66 (22.04)^b

*Means followed by the same letters are not statistically different (5%)
( ) – standard deviation

DISCUSSION

The effect of ionizing radiation delivered during radiotherapy treatments on dental materials, is not well documented . In the present study, the effect of radiation on the radiopacity and flexural strength of a resin-based composite material was studied. The use of restorative materials with adequate radiopacity is fundamental in Restorative Dentistry[12]. The advantages of restorative materials that present higher radiopacity than adjacent dentine include improved detection of recurrent caries, detection of voids within the restoration, identification of gingival overhangs and steps, and location and delineation of the pulp chamber[13]. The radiopacity of composite resins should be higher than that of dentine and similar to or slightly greater than that of enamel[4]. The ISO standards consider that the restorative material should present radiopacity at least equal to or greater than that of the same thickness of aluminum[5-6].

Several studies establishing the radiopacity of resin-based materials using radiographic densitometry have been previously published[3-4,14-15]. Recently, digital imaging techniques have been widely used in dental X-rays. The digital images obtained by the indirect or direct methods may be evaluated using specific software programs[4,13]. In the present study, the digital radiography images were manipulated by Digora Software for Windows 1.51, allowing the determination of the radiographic density. Gürdal & Akdeniz[4] related that digital analysis programs quantify the radiopacity of composite resins more efficiently than conventional techniques of radiographic densitometry, allowing resin-based restorative materials to be more precisely discriminated from dentine and caries lesions.

The degree of radiopacity of a composite resin is controlled by the manufacturer through selection of the polymer matrix and the chemical nature of the filler particles, as well as their size, density and addition level[12]. The analysis of the composite resin in this study showed that its radiopacity was not statistically modified by the radiotherapeutic doses used.

The resistance of a dental material may be considered to be related to its clinical performance[16]. Flexural strength, also known as transverse strength, is the measurement of its resistance to a bar (supported in each extremity) under a static load[17]. The flexural strength test is a combination of compressive and tensile tests and includes elements for measurement of the proportional limit and the elasticity modulus[18-19].

The findings of this study demonstrated no significant difference in the values of flexural strength for samples that had received the radiotherapeutic doses, compared to those of the control group. Despite this, a tendency towards a gradual increase in values was observed up to the radiotherapeutic dose of 50 Gy. The size and volume of filler particles, the monomer composition of the resin and the polymerization conditions have been shown to influence the properties of the composites[19]. Concomitantly to the emission of the gamma rays, radiotherapy also supplies energy to the radiated surface[20]. This may cause an increase in the degree of conversion of monomers into polymers, as occurs when heat is supplied during the polymerization of the composite resin[21-22].

When even higher radiotherapeutic doses, such as 60 Gy, were used in this study, flexural strength values began to decline; however this alteration was not statistically different compared to the other groups. According to Cruz et al.[23], the ionizing radiation is capable of modifying the microstructure of dental composites, glass ionomer and ceramics, especially with high doses of irradiation. This could explain the tendency towards a decline in the flexural strength values with the high dose of 60 Gy.

Future research with regard to other physical, mechanical and biological properties will be necessary to further clarify the effect of radiation on the diverse restorative materials used, as well as their interactions with the oral structures in which they are inserted.

In conclusion, within the limitations of this study, no significant differences were observed in the radiopacity and flexural strength values of non-irradiated samples and of those irradiated with 30, 40, 50 and 60 Gy.

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