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In vitro effect of gamma radiation on morphology structural, hardness and bending strength of dental porcelain

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ABSTRACT

Oral cancer patients receiving gamma radiation as primary or supplementary treatment, commonly have a variety of dental restorations. The resulting damage to radiated dental restorations is proportional to the amount of energy absorbed, which is referred to as the 'dose'. The effect of gamma radiation at therapeutic dosage level, (10, 20 and 30 Gy), on structure, hardness and bending strength of dental porcelain were studied and analyzed in vitro. Exposure to gamma radiation doses caused a microstructure change which affects on all measured mechanical properties of dental porcelain. The hardness, breaking load and bending strength of dental porcelain decreased after exposure to therapeutic gamma radiation doses. Care should be taken to patient who receive therapeutic gamma radiation doses and have dental porcelain.

KEYWORDS

Dental porcelain;
Gamma radiation;
Structure;
Hardness;
Bending strength.

INTRODUCTION

Dental ceramics are able to mimic natural teeth due to their excellent physical properties such as esthetics, biocompatibility, low thermal conductibility and wear resistance[1-3]. Because of these features, dental ceramics have been extensively used in several rehabilitation procedures, including inlays, onlays, crowns and porcelain veneers[4]. Surface smoothness is an important consideration for all fixed dental prosthesis as it has been shown to that the gingiva responds best when it is in contact with a smooth surface[5]. Dental ceramics have different microstructures, chemical compositions, and properties. Feldspathic ceramics enclose 19 weight percentage (wt%) of leucite crystals ($K_2O\,Al_2O_3\,4SiO_2$) after incongruent melting of a mixture of glass and potassium feldspar[6]. Aluminous ceramics, the feldspathic base ceramics, has increased the amounts of 40 to 50 wt% aluminum oxide crystals[7]. Potassium oxide (K2O) is a major component of feldspathic porcelains, as it is used to give the porcelain a coefficient of thermal expansion that most closely matches that of the metal alloys used in dental metal ceramic techniques[8]. The aim of our research was to study and analyze the effect of gamma radiation at therapeutic dosage level on structure morphology and mechanical properties of dental porcelain.

MATERIALS AND METHODS

Porcelain specimens fabrication

Twenty rectangular-shaped porcelain specimens (Vita VMK, Master, VITA Zahnfabrik, Germany) were prepared in a standardized manner and according to the manufacturer's directions in rectangular stainless steel split mold (40 mm- 5 mm – 3 mm). Porcelain dentine powder and liquid were mixed and then condensed into the mold using vibrator. Tissue was used to absorb excess moisture (Kleenex; Kimberly-Clark, Neenah, Wis). Then porcelain enamel powder and liquid were mixed and condensed into the mold. To compensate firing shrinkage, the amount must have a slightly larger size. The specimens were removed by gentle hand pressure and sintered according to manufacturers' instructions. All specimens were fired in a programmable and calibrated porcelain furnace (Programat P90, Ivoclar-Vivadent, Schaan, Liechtenstein) with the firing cycle. The entire specimens were coated with VITA AKZENT glaze then firing.

Tests

The specimens used in the present work are dental porcelain. The specimens were prepared in convenient shape for all tests such as microstructure, Vickers microhardness, breaking load and flexural strength. Microstructure of used specimens was performed on the flat surface of all specimens using an Shimadzu X–ray Diffractometer (Dx–30, Japan) of Cu–Kα radiation with wave length λ =1.54056 Å at 45 kV and 35 mA and Ni–filter in the angular range 2θ ranging from 0 to 90° in continuous mode with a scan speed 5 deg/min. Microhardness test of used specimens were conducted using a digital Vickers microhardness tester, (Model FM–7, Tokyo, Japan), applying a different loads for different indentation time via a Vickers diamond pyramid. The breaking load and flexural strength of used specimens were measured by using Lloyd universal testing machine (Lloyd Model TT-B, Instron Corp., Canton, MA, US).

RESULTS AND DISCUSSIONS

Any interactive effects between the incident gamma radiation beam and such dental materials might be of clinical significant if the properties of these dental materials are adversely affected. Effect of therapeutic gamma radiation on microstructure was studied by x-ray diffractometer. Figure 1 shows x-ray diffraction patterns of dental porcelain before and after exposure to different gamma radiation dosage, (10, 20 and 30 Gy). The analysis of x-ray diffraction patterns, (intensity which related to crystallinity, broadness which related to crystal size and position which related to orientation), Figure 1, shows a variation in amorphous part, main matrix peak, and other formed phases (accumulated particles or cluster) due to the interaction of gamma radiation with the matrix of dental porcelain.

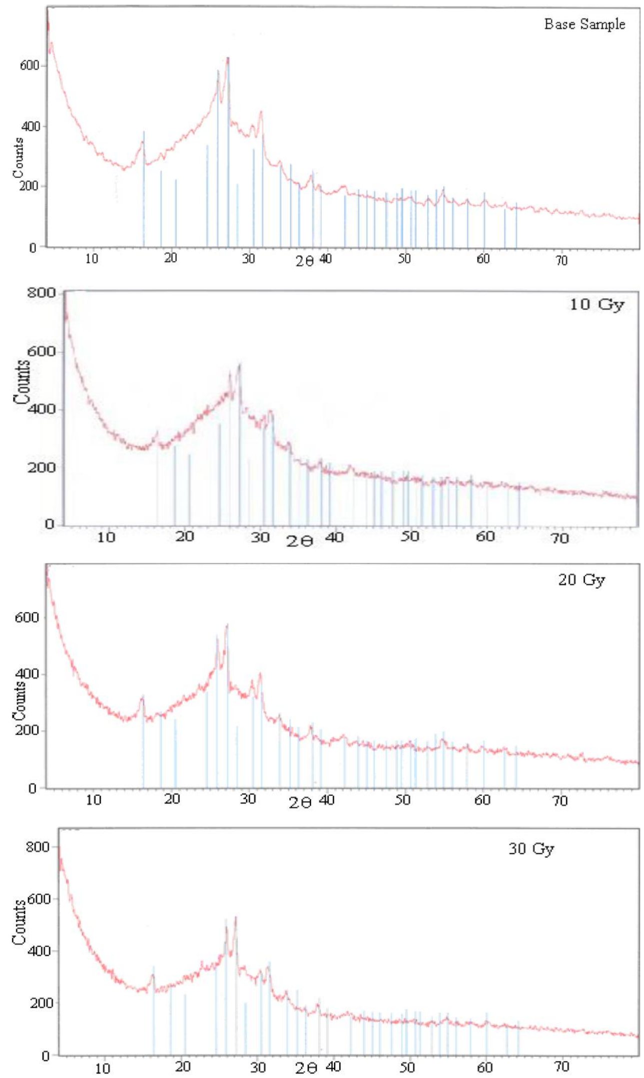

Figure 1 : X-ray diffraction patterns of dental porcelain before and after exposure to gamma radiation doses.

Hardness is a property with a low coefficient of variation when compared with other mechanical properties tested. In general hardness is defined as "Resistance of material to plastic deformation", usually by indentation. However, the term hardness may also refer to stiffness or temper or resistance to scratching abrasion, or cutting.

The microhardness value was conducted using a digital Vickers microhardness tester, applying a load of 100 g for 5 s, for dental porcelain. Vickers hardness value at different position on surface is given in Figure

2a. From Figure 2a it is seen that, variation in Vickers hardness values, that is because different places having different microstructure and different hardness or resist to the indenter. Also Vickers hardness of dental porcelain before and after exposure to different gamma radiation dosage, (10, 20 and 30 Gy), are shown in Figure 2b. Vickers hardness value of dental porcelain decreased after exposure to gamma radiation and that is agree with other pervious results[9,10]. That is because the gamma radiation could break the established bonds in porcelain matrix which results in a decrease in hardness or promotes simultaneously the linking and breaking the bond. Also gamma radiation affects porcelain matrix structure as shown in x-ray diffraction patterns.

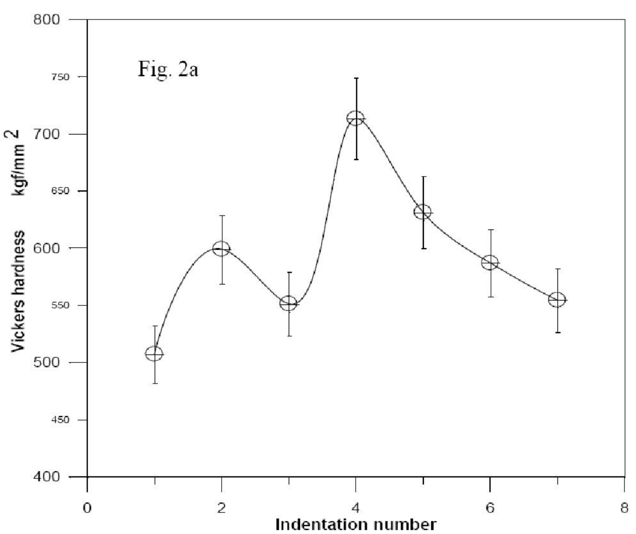

Figure 2a : Vickers hardness values at different place, position, of dental porcelain.

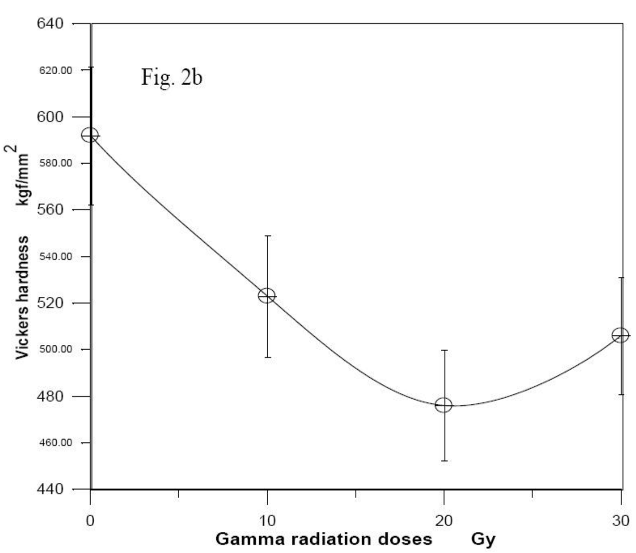

Figure 2b : Vickers hardness values of dental porcelain before and after exposure to gamma radiation doses.

Figure 3 shows the graphical description of diamond shape which caused by indenter force, applied force, on dental porcelain before and after exposure to gamma radiation doses.

Crack length and crack velocity on the surface of dental porcelain due to indenter force before and after exposure to gamma radiation doses are shown in Figure 4. The results show that, crack length and crack velocity values increased after exposure to gamma radiation doses. That is mean gamma radiation effects bond strength between atoms.

The bending strength of dental porcelain before and after exposure to different gamma radiation dosage, (10, 20 and 30 Gy), are shown in Figure 5. The bending strength values of dental porcelain decreased after exposure to gamma radiation.

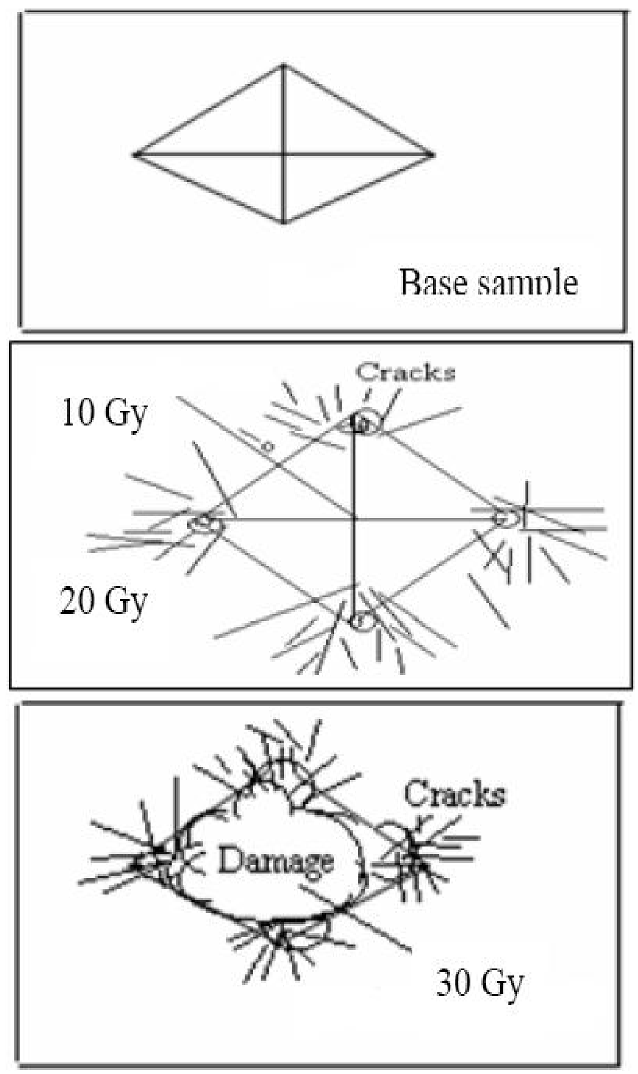

Figure 3 : Graphical description of diamond shape before and after exposure to gamma radiation doses.

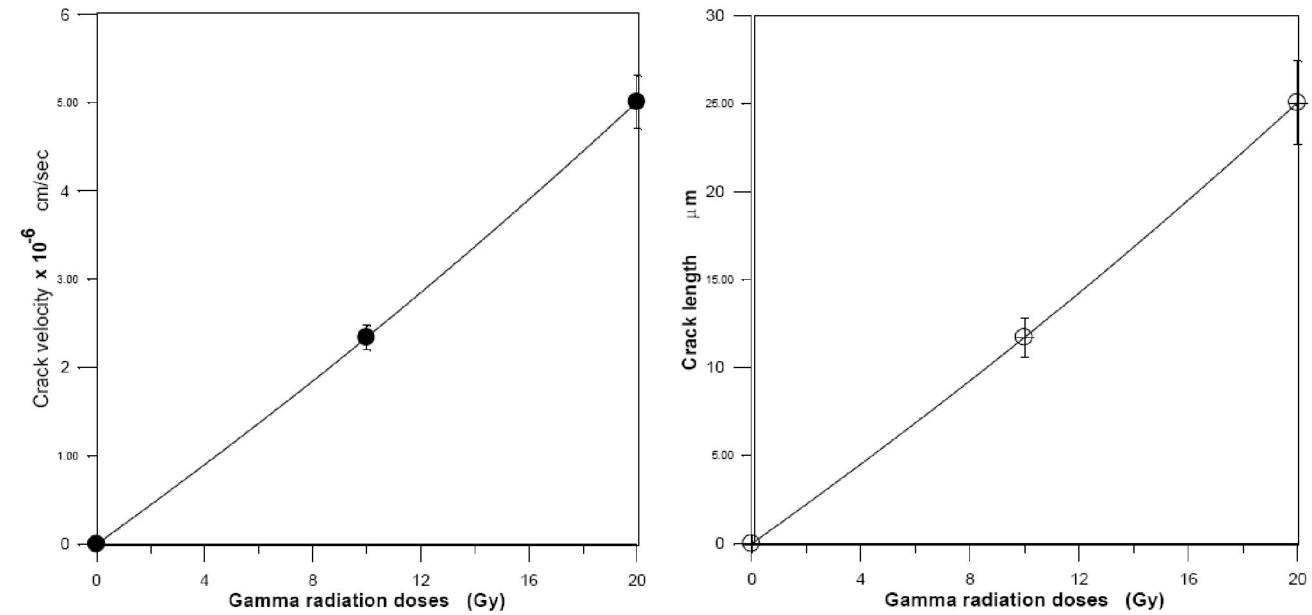

Figure 4 : Crack velocity and crack length values of dental porcelain before and after exposure to gamma radiation doses.

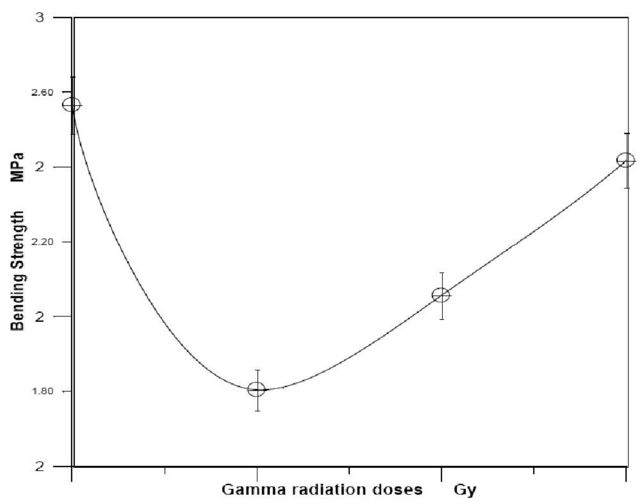

Figure 5 : Bending strength values of dental porcelain before and after exposure to gamma radiation doses.

CONCLUSION

1. Microstructure of dental porcelain changed after exposure to therapeutic gamma radiation doses
2. Vickers hardness and bending strength values of dental porcelain decreased after exposure to gamma radiation therapeutic doses.
3. Crack length and crack velocity values of dental porcelain increased after exposure to therapeutic gamma radiation doses.

RECOMMENDATION

The patients received gamma radiation as a treatment should covered a place has a dental porcelain materials.

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