ISSN : 0974 - 7532 Volume 9 Issue 6

Research & Reviews in

BioSciences

Regular Paper

RRBS, 9(6), 2014 [207-213]

Influence of titanium dioxide nanoparticles addition on antibacterial adhesion, structure and mechanical properties of conventional glass-ionomerrestorative

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ABSTRACT

The aim of this study was to investigate the effect of adding titanium dioxide (TiO_2) nanoparticles on structure, molecular structure, hardness, surface roughness and antibacterial adhesionon conventional glass-ionomer (GI). X-ray diffraction analysis shows that, adding TiO_2 caused change in GI structure such as amorphous base line, amorphous peak and accumulated TiO_2 nanoparticles. Vickers hardness and surface roughness values of GI increased after adding TiO_2 nanoparticles. Antibacterial adhesion on GI surface decreased after adding TiO_2nanoparticles.

KEYWORDS

Glass-ionomer;
Titanium dioxide;
Structure;
Hardness;
Roughness;
Antibacterial adhesion.

INTRODUCTION

Glass-ionomer systems have certain properties that make them the best direct-application dentin replacement repair materials in dentistry. Glass ionomer cements are classified into three main categories: conventional, metal-reinforced and resin-modified[1-4]. Conventional glass ionomer cements were first introduced in 1972 by Wilson andKent[5]. Addition silver-amalgam alloy powder to conventional glass ionomer cements increased physical strength of the cement. Then silver particles were sintered onto the glass, and a number of products then appeared where the amalgam alloy content had been fixed at a level claimed to produce optimum mechanical properties for glass cermet cement[6]. The aim of this work is to improve mechanical properties and antibacterial adhesion of GI by adding different a mounts of TiO_2nanoparticles.

EXPERIMENTAL METHODS

The specimens used in the present work are a commercially available conventional cure GI restorativepowder was blended in various proportionswith TiO_2 nanoparticles (Sigma–Aldrich) with particle size21 nm. Experimental materialpowders were made by mixing 1%, 3%, 5% and 7% (w/w) TiO_2. The specimens were prepared in convenient shape for all tests such as structure, molecular structure, Vickers microhardness surface roughness and antibacterial adhesion. Structure 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 λ=1.54056 Å at 45 kV and 35 mA and Ni–

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filter in the angular range 2θ ranging from 0 to 90° in continuous mode with a scan speed 5 deg/min. Molecular structurewas made using FITER spectroscopy. Microhardness test was conducted using a digital Vickers microhardness tester, (Model FM–7, Tokyo, Japan), applying a load of 10 g for 5 svia a Vickers diamond pyramid. The arrangement of hand surface (Surfest SJ201.P) which used in measurements of surface roughness. Antibacterial adhesion was performed using optical microscope.

RESULTS AND DISCUSSIONS

Structure

Effect of adding titanium dioxide (TiO_2) nanoparticles on structurewas studied by x-ray diffractometer. Figure (1) shows x-ray diffraction patterns of GI before and after adding TiO_2 nanoparticles. The analysis of x-ray diffraction patterns shows that, a variation in the main matrix peak of GI, such as amorphous base line, amorphous peak and accumulated TiO_2nanoparticles,after adding TiO_2 nanoparticles.

Molecular structure

FTIR spectroscopy has been proven to be a useful tool for determining the changes of molecular structure upon blending, irradiation, heat treatment and solvent compositions. FTIR spectrum of GI before and after adding TiO_2 have been investigated in the range starting from 500 to 4000 cm^{-1} in transmission.

The FTIR spectrum of GI before and after adding $TiO_2$is shown in Figure (2). The analysis of FTIR spectrum shows a characteristic variation, (strong, broad and position), in the IR bands of GI after adding TiO_2. That is meant that, adding TiO_2caused change in GI molecular structure.

Hardness

Hardness is defined as resistance of material to plastic deformationusually 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 10 g for 5 s, for GI before and after adding TiO_2.

Vickers hardness value of GI before and after adding TiO_2 is shown in TABLE (1). Vickers hardness value of GI isincreased after adding TiO_2. That is because TiO_2nanoparticlescaused changed in amorphous structure, decreased amorphously, with high strength of TiO_2nanoparticlesimpeded in it.

The minimum shear stress (τ_m) value of GI before and after adding $TiO_2$was calculated using the equation[7]:

$$\tau_m = \frac{1}{2} H_\nu \left\{ \frac{1}{2}(1-2\nu) + \frac{2}{9}(1+\nu)[2(1+\nu)]^{\frac{1}{2}} \right\}$$

and then listed in TABLE (1)

Surface roughness

Surface roughnessis a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. Roughness plays an important role in determining how a real object will interact with its environment. Rough surfaces usually wear more quickly and have higher friction coefficients than smooth surfaces. Roughness is often a good predictor of the performance of a mechanical component, since irregularities in the surface may form nucleation sites for cracks or corrosion. Although roughness is usually undesirable, it is difficult and expensive to control in manufacturing.

The roughness profiles of GI before and after adding $TiO_2$is shown in figure (3). Also the average surface roughness parameter Ra along the total sliding distance andother roughness parameters, (R_z, R_q, R_t and R_p),of GI before and after adding $TiO_2$are listed in TABLES (2). From the above results it is found that, the average surface roughness parameter Ra value of GIincreased after adding TiO_2up to 3% then decreased at 7%. That is because TiO_2nanoparticlescaused cracks or pits on the GI surface which increased roughness parameters of GI and then homogeneity disturbed in the surface at 7%.

Microbiology examination

The GI was treated before and after adding TiO_2at 37°C in normal pooled saliva (a pool of ten equal samples from apparently healthy individuals). Microbiological investigation revealed the *Candida spp.* is stuck on the GI surface before and after adding TiO_2. Optical micrographs, Figure (4), show the

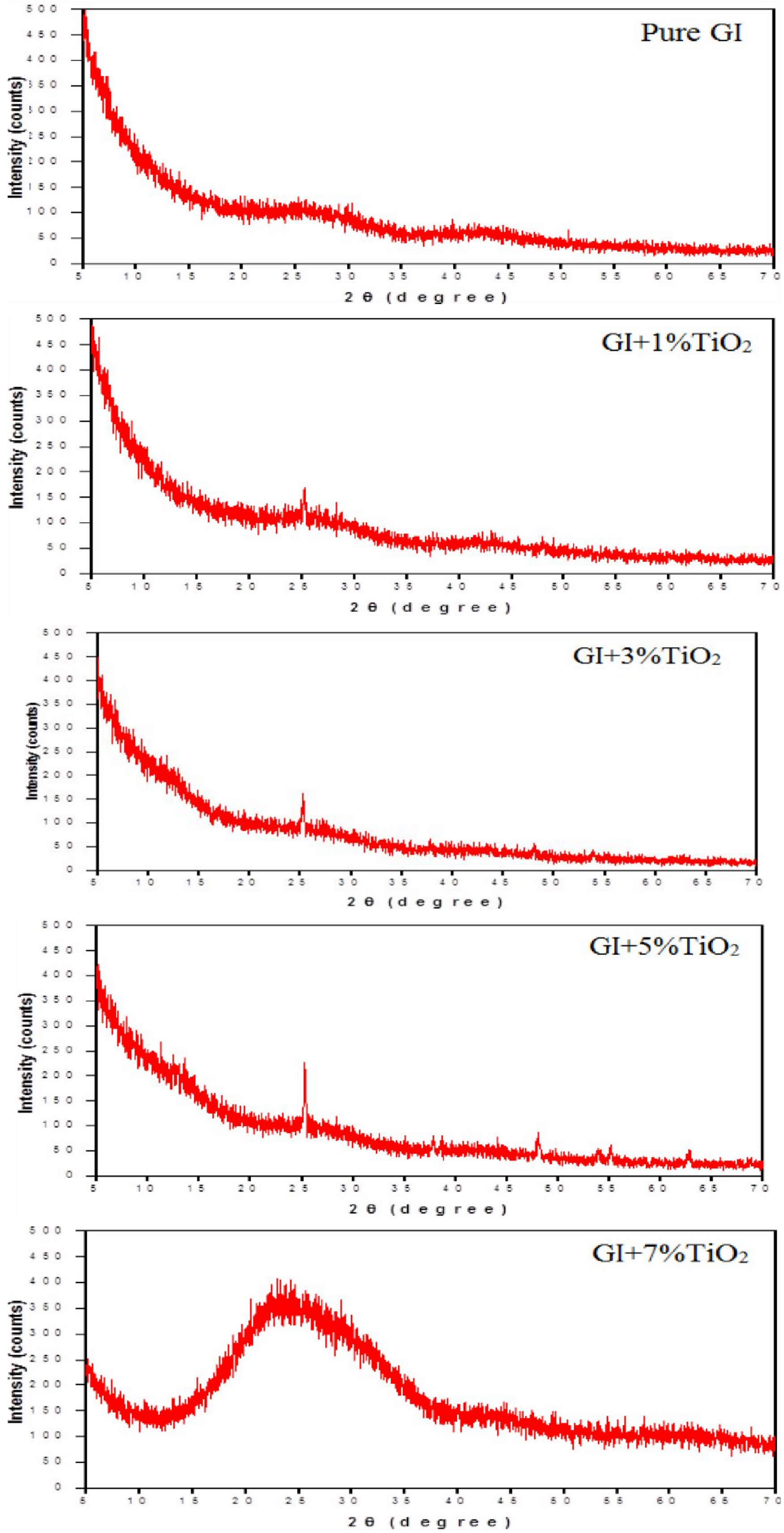

Figure 1 : X-ray diffraction patterns of GI before and after adding TiO_2

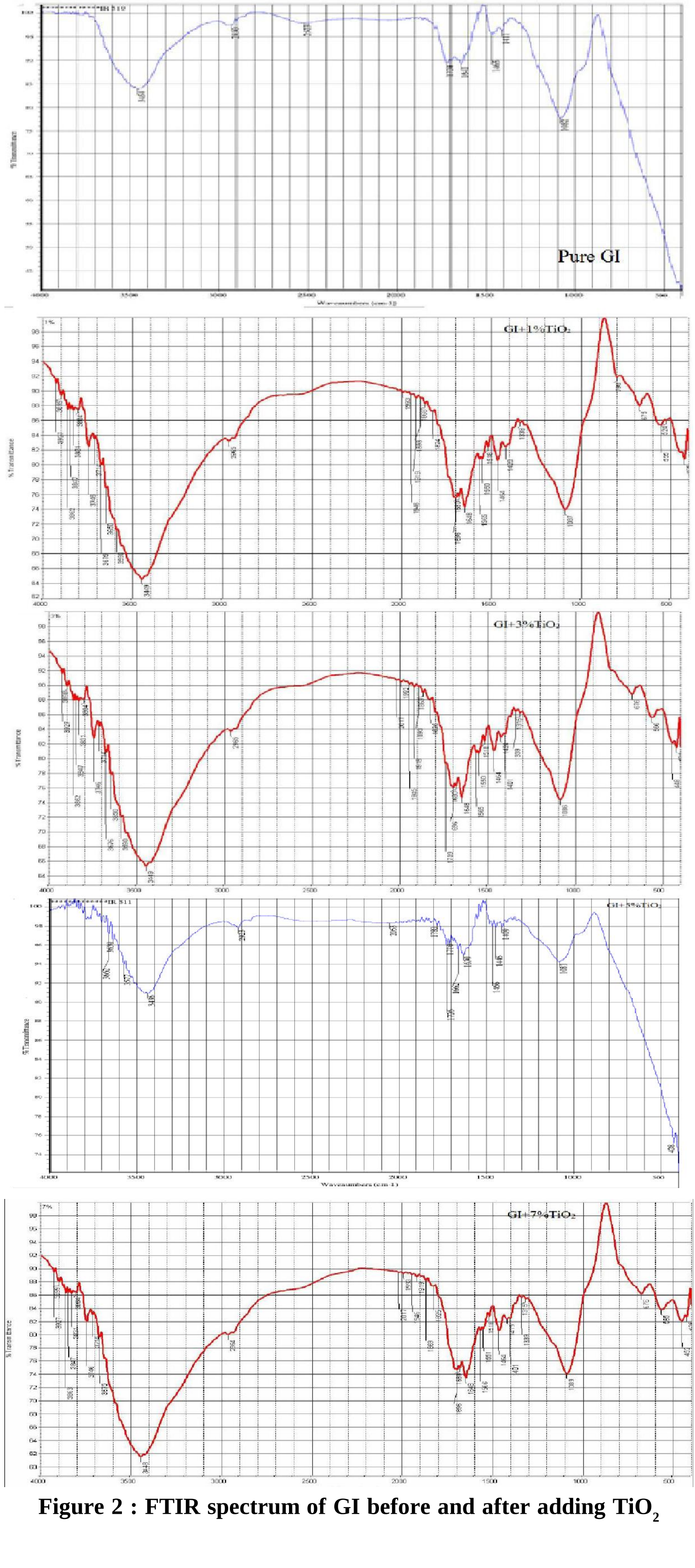

Figure 2 : FTIR spectrum of GI before and after adding TiO_2

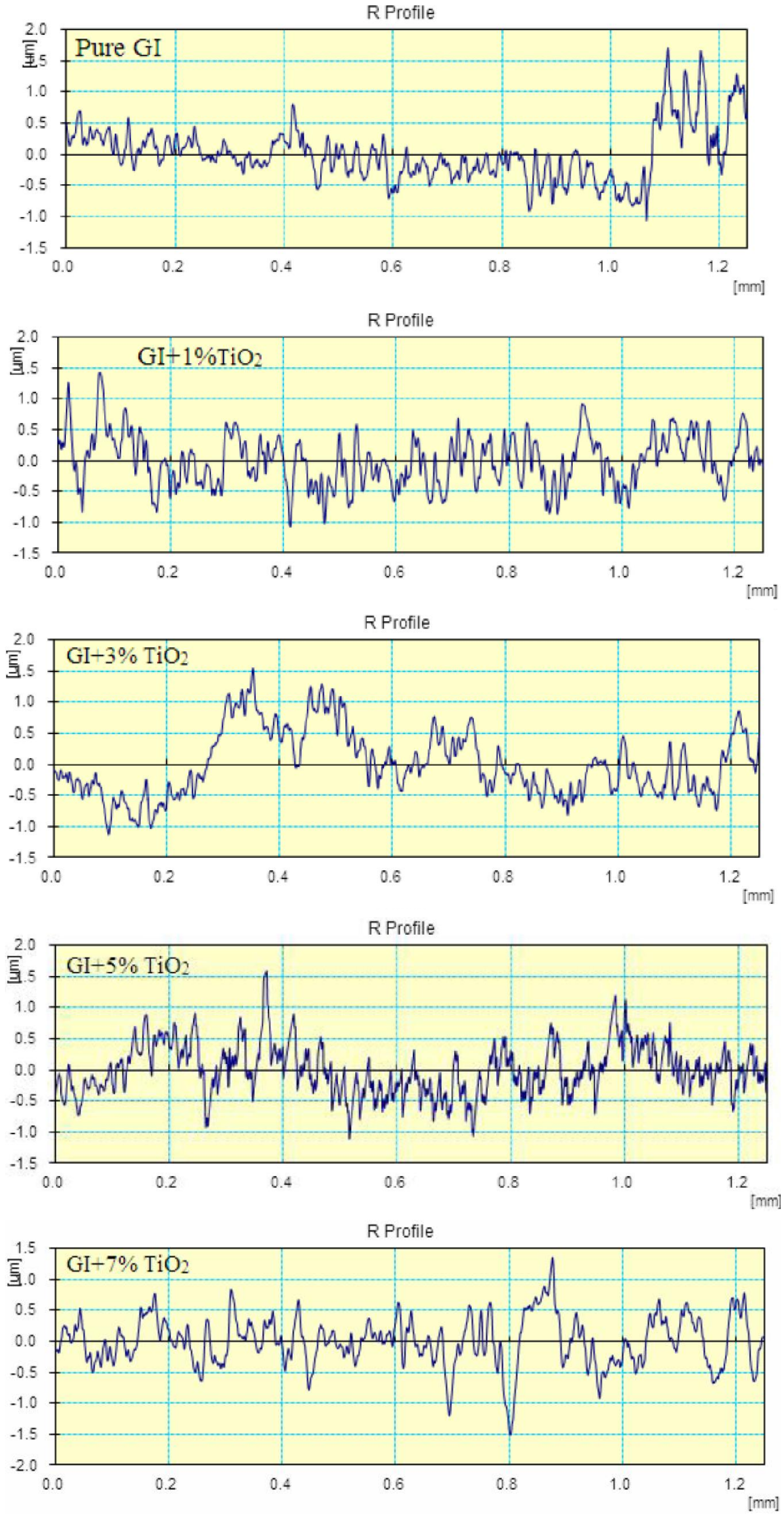

Figure 3 : Roughness profiles of GI before and after adding TiO_2

TABLE 1 : Vickers hardness and minimum shear stress values of GI before and after adding TiO_2

Samples	H_v kg/mm^2	(τ_m)kg/mm^2
Pure GI	23.95±2	7.98
GI+1%TiO_2	31.9±1.6	10.63
GI+3%TiO_2	34.5±1.2	11.5
GI+5% TiO_2	34.05±1.25	11.35
GI+7% TiO_2	34.15±1.15	11.38

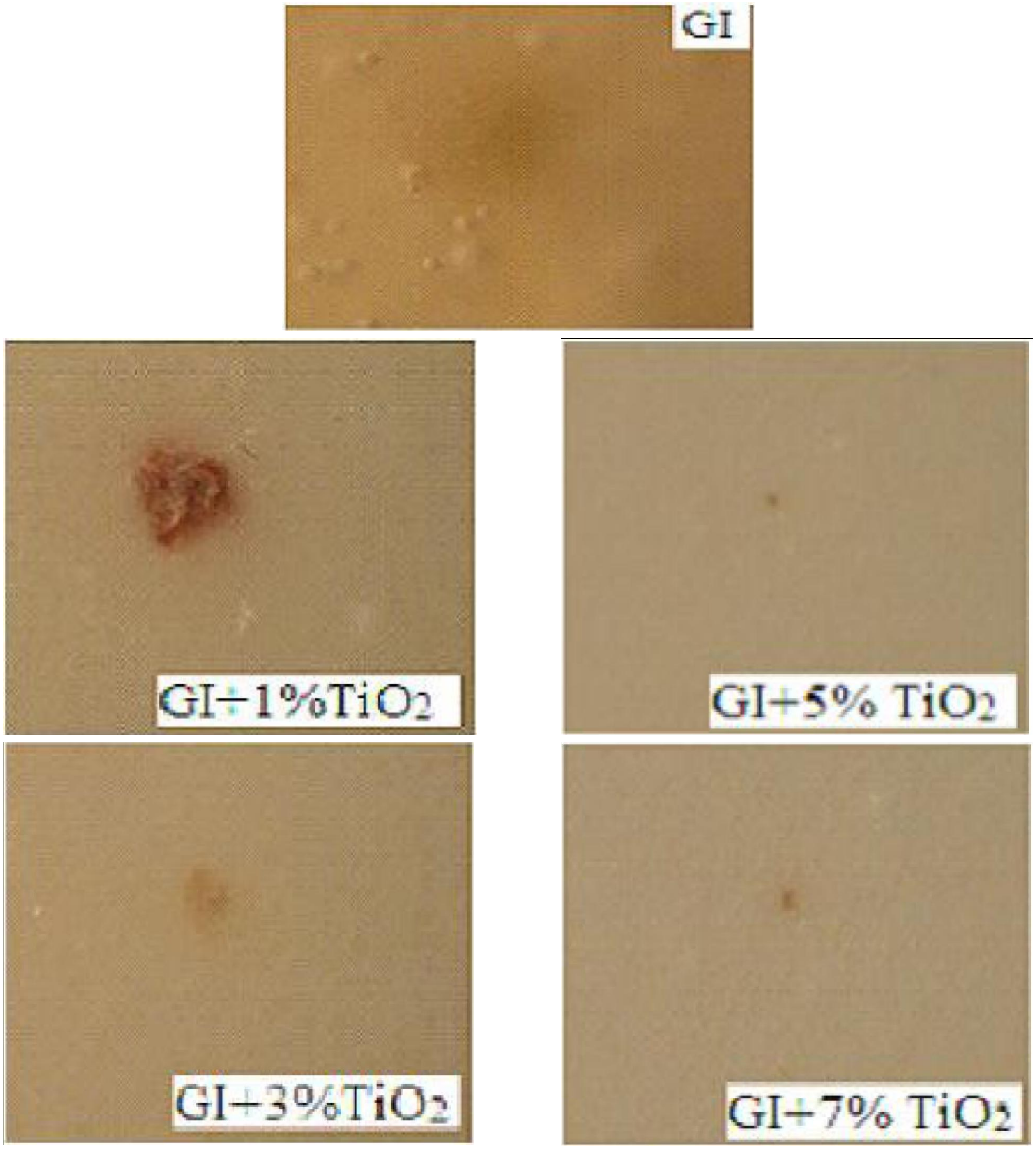

Figure 4 : Optical micrographs of GI surface before and after adding TiO_2

TABLE 2 : Roughness parameters of GI before and after adding TiO_2

Surface parameters	GI+7% TiO_2	GI+5% TiO_2	GI+3% TiO_2	GI+1% TiO_2	Pure GI
Raum	0.31	0.32	0.43	0.33	0.32
Rzum	1.81	1.86	1.45	1.75	1.43
Rqum	0.39	0.40	0.50	0.41	0.39
Rtum	2.87	2.70	2.67	2.50	2.78
Rpum	0.87	1.03	0.74	0.89	0.72

growth of *Candida spp.* on the GI surfacedecreased with increasing titanium dioxide (TiO_2) nanoparticles.

CONCLUSION

1 Structure and molecular structure of GI changed after adding TiO_2
2 Vickers hardness value of GI isincreased after adding TiO_2
3 The average surface roughness parameter Ra value of GIincreased after adding TiO_2up to 3% then decreased at 7%.
4 Growth of *Candida spp.* on the GI surfacedecreased with increasing titanium dioxide (TiO_2) nanoparticles

RECOMMENDATION

The GI+7% TiO_2 is the best direct-application dentin replacement repair materials in dentistry.

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