Microstructure and Properties of Ti-Zr Dental Alloys

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ABSTRACT

The purpose of this study is to investigate the structure, mechanical properties and grindability of a series of binary Ti-Zr alloys with Zr contents ranging from 10 to 40 wt% were investigated, with the aim of developing a dental titanium alloy. In addition, this study was also to evaluate the bond strength of experimental binary Ti-Zr alloys to dental porcelain. Through SEM with energy-dispersive spectrometry (EDS), the bonding interface between metal and porcelain substrates after the bending test was also observed. In addition, the CTE values of the Ti-Zr alloys and c.p. Ti was also evaluated. Experimental results indicated that the diffraction peaks of all the Ti-Zr alloys matched those for α Ti; no β phase peaks were found. The hardness of the Ti-Zr alloys became higher as the Zr contents increased, and ranged from 266 HV (TZ1) to 350 HV (TZ4). As the concentration of zirconium in the alloys increased, the strength, elastic recovery angles and hardness became higher, whereas the elastic modulus became lower. Moreover, the elastically recoverable angle of TZ4 was higher than that of c.p. Ti by as much as 550%. The grindability of each metal was found to be largely dependent on the grinding conditions. The TZ4 alloy had a higher grinding rate and grinding ratio than c.p. Ti at low grinding speed. The grinding rate of the TZ4 alloy at 500 m/min was about 1.8 times larger than that of c.p. Ti, and the grinding ratio was about 1.6 times larger than that of c.p. Ti. It is suggested that the TZ4 alloy has the better mechanical properties, excellent elastic recovery capability and the improved grindability using low grinding speed. The TZ4 alloy has a great potential for use as a dental machining alloy. The mean bond strengths of the Ti-Zr alloys ranged from 15.3 MPa (TZ4) to 25.1 MPa (TZ1). The TZ1 alloy had the highest bond strengths and higher than that of c.p. Ti (21.1 MPa). In addition, only the TZ1 alloy exceeded the lower limit value of the bond strengths in the ISO 9693 standard for the 3-point bending test (25 MPa). On the other hand, it was observed that the surfaces of the TZ3 and TZ4 alloy specimens on which the porcelain was fired curved slightly toward the porcelain side upon cooling. The deflection was greater for the TZ4 alloy; no bending was seen in the TZ1 alloy and c.p. Ti. This deflection was probably caused by residual stress from the thermal expansion mismatch between the alloy and porcelain. The CTE of the Ti-Zr alloys ranged from 9.37 ×10-6/oC (TZ4) to 9.88 × 10-6/oC (TZ1), and were lower than that of c.p. Ti (10.12 ×10-6/oC). The difference in the CTE between the alloy and porcelain tended to increase as the Zr component increased. It was concluded that the difference in the CTE between TZ1 alloy and Duceratin porcelain is lower than the other Ti-Zr alloys, ratifying the data obtained by bond strength testing.

Keywords : Titanium ; Titanium alloys ; Microstructure and properties ; Metal-cermic ; Coefficient of thermal expansion ; Machinability

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