Structure and Properties of Cast Ti-Sn Alloys for Dental Applications

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ABSTRACT

In this study, the microstructure, mechanical properties, grindability and machinability of as-cast Ti-Sn alloys with Sn prepared using a dental cast machine were investigated and compared with commercially pure titanium (c.p. Ti), which was used as a control. Experimental results indicated that the diffraction peaks of all the Ti-Sn alloys matched those for α Ti, and no β phase peaks or any intermediate phases were found. The hardness values of the Ti-Sn alloys increased as the Sn contents increased, and ranged from 246 HV (TS-A) to 357 HV (TS-E). Among the Ti-Sn alloys, the alloy with 30 wt.% Sn content showed the highest hardness value. All the Ti-Sn alloys had higher bending strengths, bending moduli and elastic recovery angles than those of c.p. Ti. For example, the bending strength of the TS-A alloy was higher than that of c.p. Ti by 68%, its bending modulus was higher than that of c.p. Ti by 43% and its elastically recoverable angle was higher than that of c.p. Ti by as much as 240%. Additionally, the TS-A, TS-B and TS-C alloys exhibited ductile properties. When the Sn content was TS-D or greater, the alloys showed brittle properties.

The grindability was evaluated by the volume of metal removed per minute (grinding rate) and the volume ratio of metal removed compared to the wheel material lost, calculated from the diameter loss (grinding ratio). The grindability of each metal was found to be largely dependent on the grinding conditions. The addition of Sn to c.p. Ti did contribute to improving the grindability of c.p. Ti. The Ti-Sn alloys with a higher Sn concentration could be ground more readily. The grinding rate of the TS-D alloy at 1200 m/min was about 2.8 times higher than that of c.p. Ti. Additionally, the grinding ratios of the TS-C, TS-D and TS-E alloys at 1200 m/min were about 1.8, 1.7 and 2.4 times higher than that of c.p. Ti, respectively.

Machinability was evaluated by the cutting length, which traveled by the end mill to go from one edge of the specimen for three minutes permitted calculation of the average cutting length for different metals. The experimental results indicated that alloying with Sn significantly improved the machinability of c.p. Ti in terms of cutting length under the present cutting conditions. The Ti-Sn alloys with a higher Sn concentration could be cut more readily. At 120 m/min, the lengths for TS-D were about 1.3 and 1.4 times higher than that of c.p. Ti at 200 and 300 gf, respectively. Additionally, the lengths for TS-E were about 1.7 and 1.8 times higher than that of c.p. Ti at 200 and 300 gf, respectively. For TS-D and TS-E, there was no adhesion of metal chips observed in the appearance of the cut surfaces at 120 m/min. Furthermore, they had the lowest surface roughness (Ra) values at 120 m/min.

Keywords : Dental alloy、Ti-Sn alloys、Microstructure、Mechanical properties、Grindability、Machinability

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