machine with an optical pyrometer, which can monitor temperature automatically, to solder a common base-metal alloy under different temperatures and flux concentrations. The AE technique was then applied to monitor the microfracture process during conventional mechanical tests. Furthermore, fracture modes and surfaces were examined by a scanning electron microscope. Thus, we have to the possibility to evaluate interactions among soldering temperature, flux treatment, and the resultant ultimate tensile strength (UTS) at the fracture surface of a soldered joint of a dental prosthesis.

MATERIALS AND METHODS

Sample preparation

Cobalt-chrome (Co: 64.0%, Cr: 28.0%, Mo: 5.0%, C: 0.35%) alloy (Wironit, BEGO, Almere-Haven, Netherlands) commonly used for prosthetic frameworks was selected as the soldered metal. Its main compositions and properties are shown in Table 1. A solder was chosen specifically for the Co-Cr alloy according to the manufacturer's instruction. The solder is composed of 64% cobalt, 28.5% chromium, 5% molybdenum, 1% silicon, 1% manganese, and 0.5% carbon. The melting temperature is 1100-1150 °C, and the suggested soldering temperature is 1180 °C. Flux contains Fluxsol powder (BEGO), and the composition is potassium-hydroxo-fluoroborate, which contains potassium fluoride at pH 5.3 and a density of 1.6 g/cm^3 (at 20 °C).

Specimen casting

Paraffin wax® (GC Corp., Tokyo, Japan) was fabricated into sizes, which match the wax patterns of ASTM specification no. E8M, and then was cut into 2 equal halves. Each piece was attached to a wax sprue (BEGO), and then connected with a rubber crucible former. The entire wax pattern was invested with high-temperature phosphate bonded gypsum (Wirovest, BEGO) using a vacuum mixer and vibrator. The casting ring was kept covered at room temperature for 45 min for setting. After soaking in water for 5 min, the casting ring was first put into an oven at 250 °C for 30 min, and then at 800 °C for 30 min to remove the wax. Casting was processed using a high-frequency centrifugal casting machine. After casting, the ring was bench-cooled at room temperature for 45 min, and then was plunged into room-temperature water for 5 min to remove the investment. The investment left on the specimen then was sandblasted with power-pillo (Renfert Corp., Hilzingen,Germany). The sprue was cut off with a low-speed handpiece and carborundum disk. The specimen was then finished and polished with a sanding wheel.

Soldering and AE detection

A high-frequency soldering machine (Costruzioni Elettroniche Industriali Automatismi, VicioMAGGIO, koonunga Hill, Italy), with an optical pyrometer for automatic temperature control, was used in this study as the heat source. To ensure a gap distance of 0.3 mm between the heating coil and the specimen, a dial indicator (graduation, 0.01 mm; range, 0-10 mm) was used. Specimens were placed in a jig with a gap distance of 1.0 mm. Flux was prepared by mixing the Fluxsol powder (which had been screened to the same size) and household cooking oil in proportional ratios of 2:1 (67%) and 3:1 (75%), respectively. Water was not chosen as a solvent in this study because the resultant flux became a 2-phase, inhomogeneous solution. In each soldering experiment, 0.02 ml of flux and 7 mm of solder bar were used. Soldering temperatures were set at 1150 and 1200 °C, respectively.

Table 1. Main Composition and Properties of the Parental Soldered Alloy (Wironit)

Density (g/cm^3)	Melting Range (°C)	Casting temp. (°C)	Ductile yield (%)	Elastic Modulus (N/mm^2)	Vickers hardness (N/mm^2)	Yield Strength (N/mm^2)	UTS
8.2	1320 – 1350	1640	6.2	211000	350	600	880